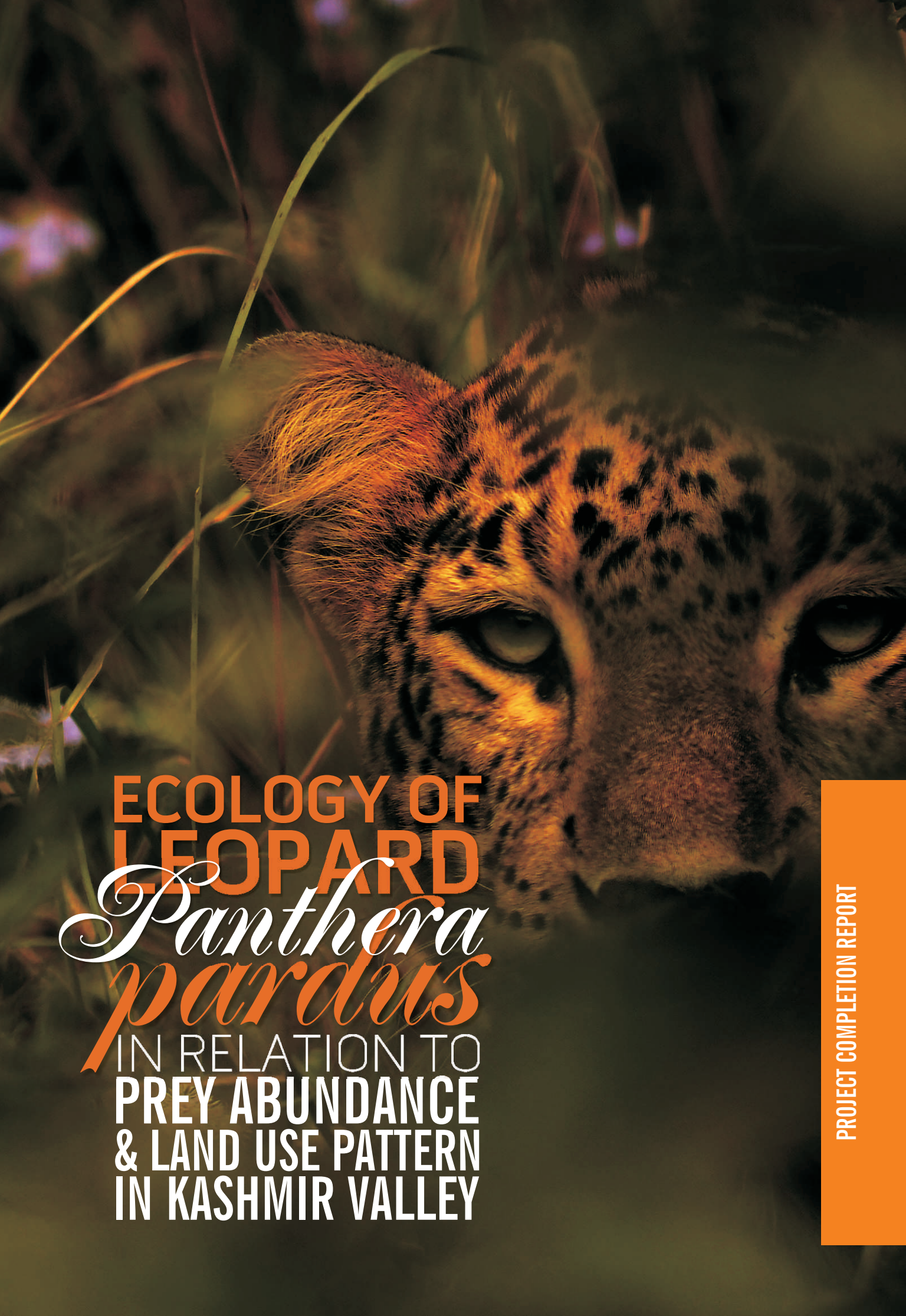

ECOLOGY OF LEOPARD *Panthera pardus* IN RELATION TO PREY ABUNDANCE & LAND USE PATTERN IN KASHMIR VALLEY

PROJECT COMPLETION REPORT

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(SR/SO/AS-28/2009)

2014

ECOLOGY OF LEOPARD *panthera pardus*

IN RELATION TO PREY ABUNDANCE & LAND USE PATTERN IN KASHMIR VALLEY

Nilanjan Chatterjee

Principal Investigator
Dr. Bilal Habib

Co- investigator
Dr. Gopi G.V.

Researchers
Athar Noor and Zaffar Rais Mir

Funding Agency

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4 RESULTS

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6 REFERENCES

Amol Nargolkar

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EXECUTIVE SUMMARY

Globally, leopard (*Panthera pardus*) is the most widely distributed and persecuted cat amongst large cat species. In India, it largely coexists with other feline species like the tiger (*Panthera tigris*) across much of its distribution range and with lion (*Panthera leo*) and clouded leopard (*Neofelis nebulosa*) in certain areas of its distribution range. Owing to its very high adaptability for surviving in varieties of habitats and opportunistic feeding behavior, it is often found to be at the center of the human-wildlife conflict. Retaliatory persecution, poaching, habitat loss and declining natural prey are some of the factors which lead to its population decline, despite being accorded protection through national and international legislations. In Kashmir Himalayas it is at the top of the food chain and an apex predator that aids in regulating prey populations. However, there has been an increase in the human-leopard conflicts in the valley which, if left unnoticed, will worsen the conservation prospects of this threatened felid. Hence, this long term study was initiated to address two major issues:

1. Conservation and management planning of the leopards in the valley is impeded by the paucity of reliable empirical ecological information and
2. Current threat levels will have to be assessed to understand and predict the impacts of anthropogenic pressure on leopards.

The objectives of the study were to estimate leopard population and prey abundance, to study the leopard feeding habits and to determine the ranging behavior of leopards. Dachigam National Park was selected to undertake ecological studies on leopards. Only the lower Dachigam was chosen as an intensive study area as the upper reaches of Dachigam are mostly high alpine areas where leopards do not inhabit.

In order to study prey abundance, line transect methodology was adopted. Transects (n = 13) were laid and monitored in the study area to obtain seasonal prey abundance. In order to estimate smaller prey (rodents) abundance, Sherman traps (n = 49) were used to estimate density. Feeding habits of the leopards were studied by collecting leopard scats (n = 714) which were later analysed using standard protocols. The population of leopard in the study area was estimated using camera traps (n = 12 pairs), deployed in 2x2 km grids in the study area to individually identify leopards with their unique coat patterns. The ranging pattern of leopards was studied by tracking the leopards (n = 3) fitted with Vectronics GPS collars.

Amongst large prey, Himalayan grey langur and Hangul were sighted with enough records to be amenable to analysis in program DISTANCE version 6.0. In total 170 groups of langur comprising of 2679 individuals and 206 groups of hangul comprising of 829 individuals were sighted across different seasons in the study area. Overall density (±SE) of langur was estimated to be 16.32 ± 1.87 km^{-2} and of hangul 5.11 ± 0.51 km^{-2} in the study area. Langur density was highest (22.05 ± 5.12/km^2) in winter season and lowest (9.35 ± 3.03/km^2) in summer season whereas, Hangul density was found to be highest (9.51 ± 1.71/km^2) in spring season and lowest (2.31 ± 0.51/km^2) in summer season. In case of rodents, the density was found to be highest during summer season (2014 ± 830.71/km^2) and lowest during winter season (1172.6 ± 442.74/km^2).

In case of dietary spectrum of leopard in Dachigam, small rodents contributed the maximum (48.05%) in

terms of percent frequency of occurrence followed by langur (14.04%). Hangul contributed 2.05% while Himalayan serow contributed only 0.20% and rhesus macaque contributed the least (0.10%) to the diet of leopard. Minimum sample size required to study food habits of leopard varied from 66 to 86 scat samples in different seasons. Jacobs' index calculated from biomass availability and biomass consumption indicates that small rodents and langur were preferred in all the four seasons. Preference of hangul was slightly higher (-0.79) during winter season as compared to summer season (-0.90).

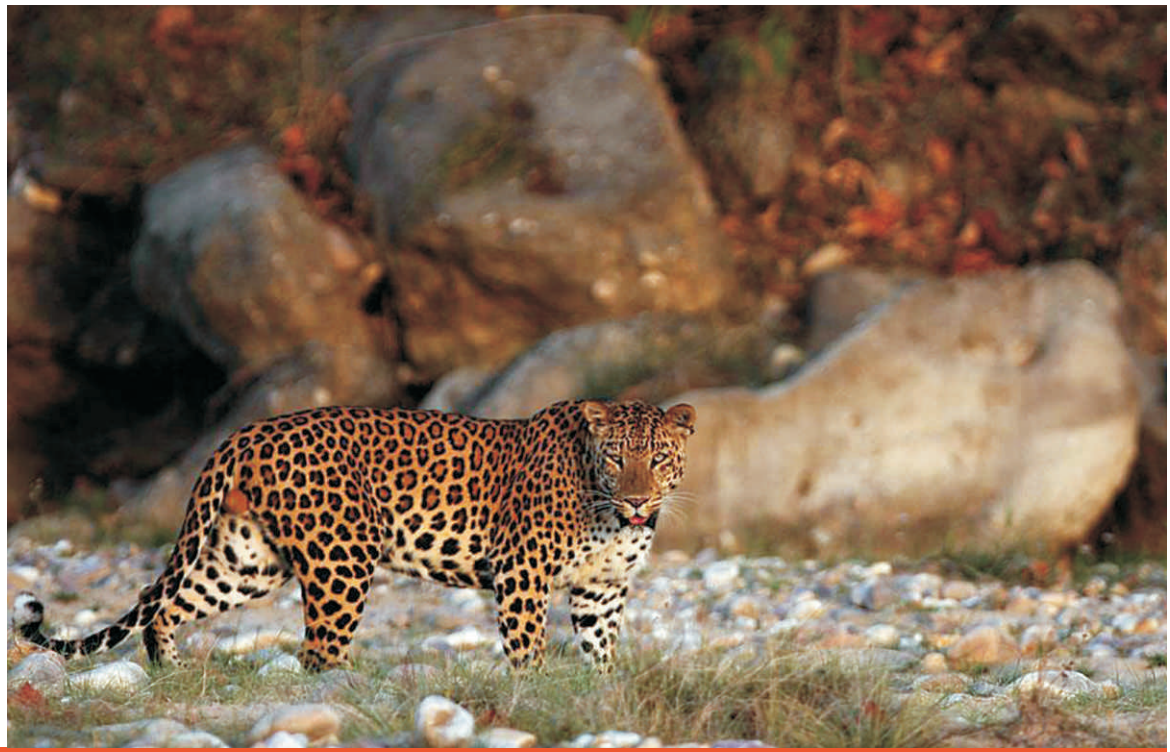
A total of 396 trap nights resulted in a total of 14 leopard photographs with 3 individual leopards. Amongst the three individuals, 2 males and 1 female was photo-captured. Although, the Null (M_0) model was selected based on highest criterion score, we selected the Heterogeneity (M_h) model because leopards are territorial animals and it accounts for heterogeneous capture probabilities between individuals. The density estimate produced by average home range radius (HHR) was 2.11 $\pm$ 1.06 individuals per 100 km^2 which was found best as density of the leopard in the study area. The relative abundance index of the leopard in the sampling duration turned out to be 3.5 per 100 trap nights.

The maximum home range (100% MCP) of the female F74 was $\sim$ 74 km^2 which was recorded during summer season. The summer home range (100% MCP) of the male was 1.96 times larger than the female leopard. The least home range ($\sim$ 41.4 km^2; 100% MCP) came up during the winter season. The increasing trend represented by the ranges (100% MCPs) of this female was winter $<$ spring (48.42 km^2) $<$ autumn (67.9 km^2) $<$ summer. The leopards showed large variation in daily distances moved during the lean season of summer. Daily displacements of the leopards were not normally distributed (Kolmogorov-Smirnov Test) for the male: M73 ($D = 0.119$, $df = 105$, $p = 0.001$), female: F71 ($D = 0.191$, $df = 105$, $p = 0.000$) and female: F74 ($D = 0.092$, $df = 105$, $p = 0.029$). Daily displacement was longer for the male leopard (median displacement = 588 m) than the female leopard (median displacement = 367.44 m). The total distance travelled by the male leopard (398.71 km) was greater than the female leopards: F74 (374.16 km) and F71 (62.91 km). In case of female leopard F74, the median daily distance travelled was highest during the winter season (0.664 km) followed by autumn (0.528 km), spring (0.506 km) and summer (0.367 km)

Findings of this study indicate that leopards are facing prey scarcity in the area, thus making them to rely upon suboptimal prey and occupy home ranges larger than other studies in the subcontinent. Leopards being opportunistic feeders have also started feeding on domestic prey in absence of sufficient wild prey, thereby elevating the human - leopard conflict in the region. Human - animal conflict being the major threat to large carnivores all across their distribution range is a big impediment in leopard conservation in the study area as well.

OBJECTIVES AS STATED IN PROJECT PROPOSAL

1. Estimation of prey density across different sites and developing a relationship between density of prey base and leopard abundance.
2. Study variation of food habits across different sites and seasons in Kashmir valley.
3. Estimate density, abundance and distribution of leopard across different study sites.
4. Study movement pattern, home range size and social organization of leopards across different sites.



G.S. Bhardwaj

DEVIATION MADE FROM ORIGINAL OBJECTIVES

All objectives aimed in the project proposal have been fulfilled as proposed.

To start with we selected Dachigam National Park for conducting ecological studies on leopards as well as their prey for the following reasons:

1. It is the first National Park in Kashmir valley with pristine ecosystem.
2. It boasts of the flag ship species of the State – Hangul (Cervus elaphus hanglu), the last surviving population of European Red Deer in India.
3. Vital role of this red deer sub-species as it is functionally a part of prey-predator dynamics where leopard (as a predator) is at the top level of the ecological pyramid.
4. More accessible in comparison to other areas of the valley which are relatively either difficult to approach or have very little lean period to work because of climatic conditions and socio-polictical reasons.

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Aug 2014

INTRODUCTION

1

Pallavi Ghaskadbi

Distribution

The first felid like carnivores appeared in the Oligocene, approximately 35 million years ago. Living cat species (sub family Felinae) originated in the late Miocene and evolved into one of the world's most successful carnivore families, inhabiting all the continents except Antarctica (Nowell and Jackson, 1996; Nowak, 1999; Johnson et al. 2006). However, the pantherine cats as a whole diverged about 6.37 million years ago while leopards about 3.72 million years ago (Johnson et al. 2006). The oldest pantherine fossils occur in Africa but molecular phylogenies point to Asia as their region of origin. This contradiction has been cleared by the recent discovery of a fossil pantherine from the Tibetan Himalayas, with the age of Late Miocene–Early Pliocene, replacing African records as the oldest pantherine, thus clearing doubts and providing robust support for the Asian origin of the pantherines (Tseng et al., 2013).

The leopard (*Panthera pardus*) has the widest geographic distribution amongst all the Panthera cats (Nowell and Jackson, 1996). However, its geographic range has been reduced in recent times, although historically the leopard was distributed throughout northern Africa and over much of sub-Saharan Africa as remnant populations, Arabian Peninsula and Sinai/Judean Desert, south-western and eastern Turkey, and through Southwest Asia and the Caucasus into the Himalayan foothills, India, China and the Russian Far East, as well as on the islands of Java and Sri Lanka (Seidensticker and Lumpkin, 1991; Nowell and Jackson, 1996; Sunquist and Sunquist, 2002). They are not found on the islands of Borneo or Sumatra (Nowell and Jackson, 1996) (Fig. 1).

In India, the leopard is found in all forested habitats across the country, absent only in the arid deserts and above the timber line in the Himalayas (Prater 2005). It occurs widely in the forests of the Indian sub-continent, through India and South-east Asia and is found in all forest types, from tropical rainforests to temperate deciduous, alpine coniferous, dry scrub and grasslands (Harrison and Bates 1991).

Population status

Leopards, because of their widespread distribution and ecological adaptability and plasticity are considered to warrant low conservation priority. However, global population status is still uncertain (Nowell and Jackson, 1996) because of difficulty in monitoring on account of their cryptic nature, large home range and low population densities (Rabinowitz, 1989; Bailey, 1993; Nowell and Jackson, 1996). Earlier, traditional pugmark census used to be the prime method of monitoring large cat abundances (Panwar, 1979; Riordan, 1998) which was later on largely criticized for lack of statistical robustness (Karanth, 1987; 1988; 1995). On the other hand, remotely used camera-traps in combination with standard capture-recapture population models provide useful and statistically robust alternative for non-invasive monitoring of large carnivores to derive logical density estimate (Karanth, 1995; Karanth and Nichols, 1998). Density estimates of leopards in different areas across the range vary from ~1 to 30.9 individuals 100 km^{-2} with no obvious relationship with broad habitat type (Kostyria et al., 2003; Khorozyan, 2003; Chauhan et al., 2005; Spalton et al., 2006; Ngoprasert et al., 2007; Edgaonkar, 2008; Henschel, 2008; Sankar et al., 2008; Simacharoen and Dungchantrasiri, 2008; Harihar et al., 2009b; Wang and Macdonald, 2009a; Chapman and Blame, 2010; Selvan et al, 2014), but the site-specific factors such as levels of prey availability, fine-scale habitat variables, presence of co-predators and human disturbance might have an influence on the density estimates.

Diet and prey availability

It might be predicted from its widespread distribution, that the leopard can be found in different habitat types representing its wide habitat tolerance and versatility as a generalist predator (Jerdon 1867, Nowell and Jackson, 1996). Distribution and abundance of carnivore species depends on the availability of different sized ungulate prey species (Karanth and Nichols, 1998; Carbone and Gittleman, 2002). However, information on the abundance of ungulate prey species is sparse in most of the Himalayan ecosystems (Seidentiscker, 1976; Dinerstein, 1980; Tamang, 1982; Malla, 2009; Wegge et al., 2009).

Bailey (1993) noted a minimum of 92 prey species were used by leopards in sub-Saharan Africa, and known prey ranges in size from arthropods (Fey, 1964) to an adult male Sambar or Gaur (Sedeinsticker, 1976a, Karanth and Sunquist, 2000). Despite such an enormous prey size range, leopard diet is generally dominated by medium sized wild ungulates (<50 kg body weight) (Schaller, 1967; Essenberg and Lockart, 1972; Seidensticker, 1976a; Johnsingh, 1983; Rabinowitz, 1989; Seidensticker et al., 1990; Johnsingh, 1992; Bailey, 1993; Karanth and Sunquist, 1995; Edgaonkar, 2008; Wang and Macdonald, 2009). Recently, Hayward et al. (2006) reviewed 33 studies on leopard feeding ecology and found that leopards preferentially prey upon species within a weight range of 10 – 40 kg. Low densities of medium sized ungulate prey force leopard to switch to more abundant sub optimal prey such as rodents

(Ramakrishnan et al., 1999; Sankar and Johnsingh, 2002) and/or secondary prey (livestock and dogs) (Seidensticker et al., 1990; Edgaonkar and Chellam, 2002; Goyal et al., 2007; Chauhan, 2008; Shah et al., 2009). Recent study on Asia's carnivore guild illustrates little dietary niche differentiation between the carnivore guild (Hayward et al., 2014).

Spacing and habitat utilization

The leopard is solitary and apart from mating, interactions between individuals appear to be infrequent (Jenny, 1996). Like other solitary carnivores, the female leopards are expected to space themselves according to resource availability, while the male spacing is based on both receptive female and availability of food resources. Reported home range of leopard varies from 6 km^2 in Nepal (Seidensticker et al., 1990) to over 2000 km^2 in African arid ecosystems (Bothma et al., 1997), however generally male territories range between 30 and 78 km^2, whereas 15 – 16 km^2 are common for females (Nowell and Jackson, 1996). In the Indian subcontinent in Nepal Himalayan ecosystem, the ranges of the female leopards have been estimated to range 5.2 - 17km^2, whereas for male leopard it was a maximum of ~ 48 km^2 (Sunquist 1983; Scidenstickeret. al.,1990; Odden and Wegge, 2005).

Singh et. al., (2004) recorded largest home range for female leopard (76 km^2) in the Gir National Park and Sanctuary, Gujarat. However, the average home range of the male leopard in Gir was estimated to be 12.5 km^2. In Wilpattu National Park, Sri Lanka, the home range of adult female was estimated to be 8-10 km^2 by Muckenhim & Eisenberg (1973).

The broad habitat utilization of leopard is not unanimous and shows a tendency of utilization on the variety of forest and grassland habitats (Marker and Dickman, 2005). Mixed deciduous and dry ever green forest types, flat slope and areas close to stream channels are found important landscape features for leopard habitat selection in Thailand (Simcharoen et al. 2008). Leopard habitat use intensity increases positively with distance from the human disturbances (Ngoprasert et al., 2007). Habitat use of leopard is reported to be influenced by the presence of other large carnivores like tiger and lion (Seidensticker, 1976a).

Human-leopard conflict

Human-leopard conflicts most commonly involve killing of livestock, occasionally involve attacks on humans and leopard persecution (Mizutani, 1995; Nowell and Jackson 1996; Negi, 1996; Edgaonkar and Chellam, 1998; Mukherjee and Mishra, 2001; Goyal et al., 2007; Kissui, 2008; Tamang and Baral, 2008; Chauhan, 2008; Dar et al. 2009; Inskipp and Zimmerman, 2009). Therefore, effective conflict management strategy is essential for conservation of leopards. Any attempt to mitigate human - leopard conflict (Arthreya, 2006; Arthreya and Belsare, 2007) and improve the conservation of the species should be based on an explicit understanding of the conflict patterns (Dar et al., 2009) and perceptions.

Conservation and management

Habitat destruction, loss of wild prey, poaching for skins, bones and claws, and poisoning carcasses of livestock killed by leopards are the significant threats to the species. The Wild Cat Status Survey conducted by the Species Survival Commission (SSC) Cat Specialist Group of the International Union for the Conservation of Nature (IUCN) has categorized leopard as one of the Near Threatened felids (Henschel et al 2008). The leopard is placed in Appendix I in the Convention on International Trade in Endangered Species (CITES), and is protected under national legislation throughout most of its range (Nowell and Jackson, 1996). In India, it is accorded highest level of protection by being listed under the Schedule I of the Indian Wildlife (Protection) Act, 1972.

Major threats

Like other large carnivores, leopards are declining throughout their range due to habitat conversion, prey depletion, intense persecution and poaching for trade (Nowell and Jackson, 1996; Ray et al. 2005; Breitenmoser et al., 2006, Breitenmoser et al., 2007). Main threat of leopards in African rainforest is probably competition with human hunters for prey (Henschel, 2008). Although, leopards are found

throughout most of their range however, their populations have dramatically reduced over the last hundred years (Nowell and Jackson, 1996; Nowak, 1999; Uphrkina, 2001; Henschel et al., 2008). A rapidly increasing threat to leopards is the poisoning of carcasses targeting carnivores, either as a means of predator control or incidentally (Henschel et al., 2008) and poaching for international trade (Breitenmoser et al., 2006; 2007).

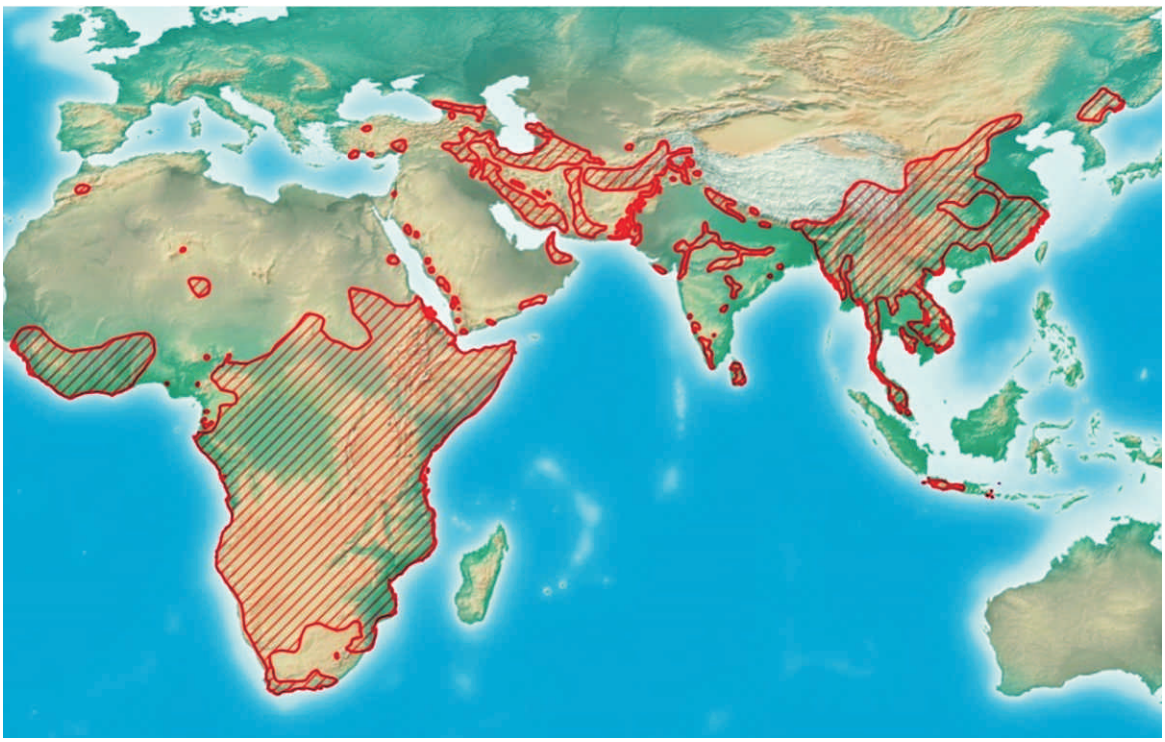

Fig. 1: *Distribution range of leopard across the world.*

*IUCN 2013. *The IUCN Red List of Threatened Species.Version 2014.1.*<http://www.iucnredlist.org>. Downloaded on 13 July 2014

Background of the project

Human-leopard conflict is reported from across its distribution range in India. However, least academic and conservation attention has been given to this species, while, most of the resources go towards the conservation of other charismatic large cats like lions and tigers. The adaptability of the leopard makes it possible to exploit the wide range of habitats and varied landscape. In the recent years, poaching of leopards has increased tremendously at an alarming rate (Athreya 2012) which has made us assume that population is threatened due to the rapid rise in poaching. Leopards also face other threats like, habitat fragmentation, encroachment of the natural habitat, lack of prey base, etc. Recent survey conducted in the state of Jammu and Kashmir on human-leopard conflict reported 60 cases of attacks on humans from 1999 – 2007 (Iqbal, et al., 2005; Singh, et al., 2007). The cause of movement of the leopards outside the protected areas of Jammu and Kashmir is governed by

different factors. Outside the state of J&K, crops like sugar-cane provide ample cover for the leopards to survive outside the protected areas (Athreya et. al. 2011) but in the state of the Jammu and Kashmir no such cover is available to leopards which make them more prone to conflict. Harsh winters with low availability of prey base will defiantly govern some distinction in the ecology of the leopards here in comparison to other states. The political instability in the Kashmir region for more than last two decades has put the wildlife research at remote corner. Despite, a recent rise in human - leopard conflict in the state of the Jammu and Kashmir, there have been no academic or conservation attention given to better understand and scientifically mitigate this problem. This project was envisaged to collect baseline empirical ecological information to aid in management of the species in this biodiversity rich landscape.

STUDY AREA

2

G.S. Bhardwaj

Himalayan mountains are rich in biodiversity and provide life support system to millions of people. The phase-wise evolution of the Himalayas over 45–60 million years period has provided novel opportunities to the floral and faunal elements, arriving from all directions, to colonize the newly evolving landscapes and later diversifying into unique ecosystems (Das, 1966; Singh and Singh, 1987). Indian Himalaya Region (IHR) spans over twelve states of India and is distinguished as global biodiversity hotspot (Myers et al 2000). The present study was carried out in North West Himalayas in Kashmir division of state J&K, India. Dachigam National Park in Srinagar was selected as the intensive study site.

Physical features

The mountain ranges enclosing Dachigam are a part of the great Zanskar Range which forms the north-west branch of the central Himalayan axis, bifurcating near Kulu and terminating in the high twin peaks of Nun and Kun. The fold of this range is

thrown into a number of undulations enclosing narrow gullies, and broader outflanked gullies locally known as 'Nar'. Two steep ridges, one rising from near Harwan Reservoir and another to the east of 'New Theed' form the natural boundaries of the National Park. The series of undulations presents a variety of slope aspects, supporting an array of vegetation types. A number of rocky cliffs and steep slopes break the uniformity of the main slopes. The main Dagwan River originates from Marsar Lake and flows into Harwan Reservoir; it is fed throughout its course by a network of streams draining through the numerous gullies.

Location

Dachigam National Park lies between 34 05 N - 34 11 N and 74 54 E -75 09 E (Fig 2.1) and the area comes under the civil jurisdictions of Srinagar, Anantnag and Pulwama districts. It comes under 2A Bio-geographic zone and 2.38.12 (Himalayan Highlands) bio-geographical province (Rodgers et al. 2000). It is 21 km north-east to Srinagar the summer capital of Jammu and Kashmir state situated in Zabarwan mountain range of the Great Himalayas. Nearest Airport and railhead stand 32 and 315 km away, respectively.

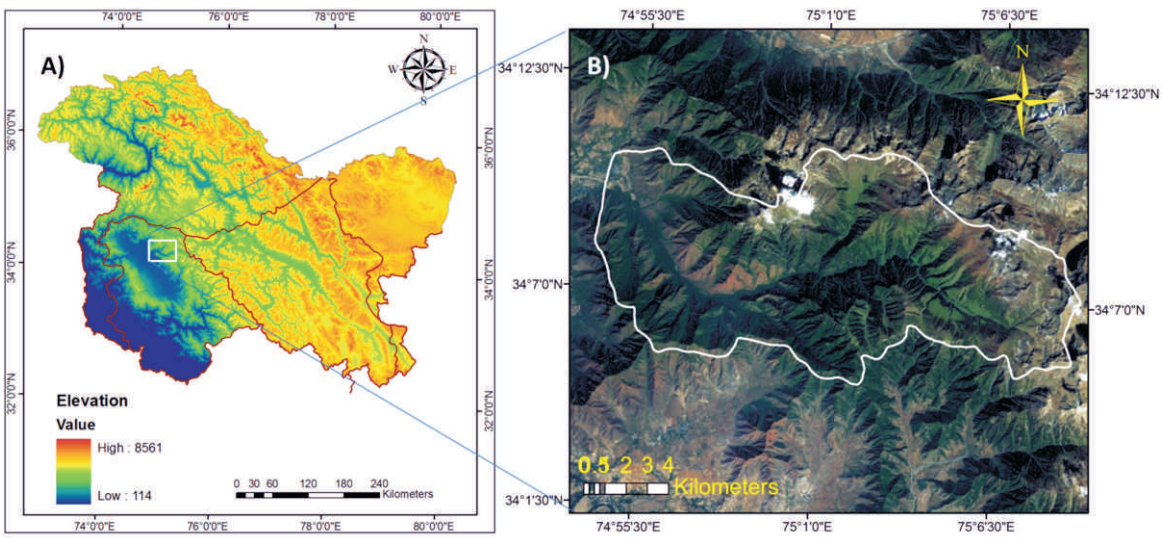

Fig. 2.1: *Geographic location of Dachigam National Park in Jammu And Kashmir State: A) Jammu and Kashmir B) Dachigam NP.*

History

The name of the park comes from the Kashmiri word Dah which means 10, chi means are and gam means village so “ten villages”. Before the existence of the park there were 10 villages which were later on translocated from the area due to the formation of a game reserve or 'rakh' by the Maharaja of Jammu and Kashmir. The name of the National Park was given in the memory of these 10 villages. Inside the park there are many nallahs which are named after the translocation of those villages. This area had diverse flora and fauna by keeping this in mind maharaja made it a 'forest reserve' (rakh) for himself and for his guests.

Constitution

Dachigam National Park remained a hunting reserve of the Maharaja of Jammu and Kashmir for a long time from its establishment in 1910 until 1947, after which, the management was handed over to Department of Hospitality and Protocol (Fisheries Department, Directorate of game preservation) and subsequently to the Forest Department. It was

Leopard Ecology Project

managed under the Wildlife wing of Forest Department and later Dachigam was declared as a sanctuary by state order no. 276/C in 1951 (Holloway, 1970; Holloway and Wani, 1970). Dachigam Wildlife sanctuary was upgraded to National Park on 4 February 1981 (state order no. FST/20) by the Govt. of Jammu and Kashmir. The management of Dachigam NP was handed over to the newly formed Department of Wildlife Protection, Jammu and Kashmir 1982 after separation from Forest Department. The park is divided into two administrative units *viz* Lower and Upper Dachigam which are administered by Central and South Wildlife Division respectively. Dachigam National Park is surrounded by many conservation reserves which are contiguous to the boundaries. There are many villages which are located on the periphery of Dachigam where managing wildlife conflict has become challenging task.

Climate

The climate of the area can be described as Sub - Mediterranean to typically temperate with high degrees of variation in precipitation and dryness. Kashmir valley has four distinct seasons in a year: spring (March - May), summer (June - August), autumn (September -November) and winter (December - February). The mean temperature recorded in summer is maximum 27^{0}C and minimum in winter of 2^{0}C. Average rainfall recorded is 660mm but there is no definite rainy season unlike other parts of the country (Ahmad et al. 2006).

Vegetation

The altitude range of lower Dachigam varies from 1700 m to 3500 m and thus has a complex mixture of vegetation types with broad leaf mesophyll forest of maple (*Acer caesium*), mulberry (*Morus alba*), *Ulmus* spp. *Rhus succidiadiana* and walnut (*Juglans*

regia), Hatab (*Parrotiopsis jacquemontiana*) and a variety of conifers such as deodar (*Cedrus deodara*), blue pine (*Pinus wallichiana*), spruce (*Picea smithiana*), and Fir (*Abies pindrow*) growing in an altitudinal sequence. Upper Dachigam altitude ranges from 2000 m to 4700 m. It comprises vegetation gradient of sub alpine community of forest followed by scrub vegetation of birch (*Betula utilis*) and rhododendron (*Rhodo dendron spp.*) interspersed with meadows of herb rich grass lands over 3300 m.

As per Champion and Seth (1968) the vegetation of Dachigam is typical of Himalayan moist temperate forest; sub-alpine forest and alpine forest type and can be classified into following types.

1. **Moist Temperate deciduous forest**
2. **Parrotiopsis scrub forest**
3. **Western Himalayan low level blue pine forest**
4. **Western mixed coniferous forest**
5. **Deciduous alpine scrub**
6. **Western Himalayan sub-alpine birch - rhododendron forest**
7. **Dwarf juniper scrub**
8. **Dry temperate scrub**
9. **Alpine pastures.**

A detailed vegetation study was also carried out by Singh and Kachroo (1976) in Lower Dachigam. The dominant species in order of frequency constituting the flora of Dachigam are; Compositae; Gramineae; Rosaceae; Labiatae; Leguminaceae; Cruciferae; Umbelliferae; Boraginaceae; Caryophyllaceae and Cyperaceae (Singh and Kachroo 1976).

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Fauna

As other Himalayan ecosystems Dachigam National Park supports rich faunal diversity. Dachigam National Park is represented by several mammal species having high conservation value, which include Hangul (*Cervus elaphus hanglu*), Himalayan musk deer (*Moschus chrysogaster*), serow (*Capricornis thar*) and snow leopard (*Uncia uncia*). Other species found in the Park include Asiatic black bear (*Ursus thibetanus*), leopard, Himalayan grey langur (*Semnopithecus ajax*), rhesus macaque (*Macaca mulatta*), red fox (*Vulpus vulpes*), jackal (*Canis aureus*), jungle cat (*Felis chaus*), leopard cat (*Prionailurus bengalensis*), Small Indian civet (*Viverricula indica*), long tailed marmot (*Marmota caudata*), yellow-throated marten (*Martes flavigula*), Himalayan weasel (*Mustela sibirica*) and Indian Crested Porcupine (*Hystrix indica*). Wild boar (*Sus scrofa cristatus*) was reported after 30 years during the camera trapping exercise carried out in this study (Ahmad et al, 2013). Besides, the park inhabits a good diversity of insects, reptiles and avifauna. A list of avifauna of Dachigam National Park is shown in Appendix I.

Although, Dachigam National Park is an ideal place for researchers owing to its rich biodiversity and unique ecosystem, it is almost neglected in terms of research for long time because of more than two decades of socio-political turmoil in the state of Jammu and Kashmir. Some of the pioneering studies carried out here in the past include – observations on various behavioral aspects of the hangul deer like rutting, seasonal migration and food availability by the veterans like J. B. Schaller (Schaller, 1969). Kurt (1977, 1978) estimated the food availability in winter and spring seasons by analyzing 180 plots along 8 transects through the lower Dachigam. Later on, he further reported that hangul no longer migrated to upper Dachigam due to excessive disturbance in that area but remain in the lower Dachigam throughout the year (Kurt, 1979). Shah et al. (1983) studied the winter diets of the hangul. Manjrekar (1989) studied the food habits of the Asiatic Black Bear. After a large gap recently some more studies were conducted on prey-predator relationships between hangul and leopard by Iqbal et al. (2005) and on some ecological and conservation aspects of hangul by Ahmad (2006) and Ahmad et al. (2009). Following this, a long term monitoring program was initiated by the Wildlife Institute of India to study ecological aspects of the Asiatic Black Bear which included looking into spatial organization of the black bears through satellite telemetry (Charoo, 2012 and Sharma, 2012).

METHODOLOGY

3

Bivash Pandav/Camera Trap pic

Prey abundance

In order to get a fair knowledge of the area, a reconnaissance was carried out in the early months of the study period in whole of the study area. The population of Hangul and Himalayan Grey Langur were then estimated on seasonal basis using Distance sampling technique (Burnham, Anderson & Laake, 1980; Buckland et al., 1993). In total 13 line transects (ranging from 1.5 to 2.5 km in length) were laid in different habitats covering a distance of 26.05 km (Fig. 3.1). Each transect was walked 12-18 times each season during morning hours. Total transect effort was 1499 km for all seasons (Table 3.1). Transects were monitored in morning hours between 6.00 to 10.30 AM. In each monitoring, the number of clusters detected, cluster size, cluster composition, sighting distance (measured by a laser range finder), sighting angle (measured by see through compass - Sunto) and geographic coordinates (recorded by a GPS - Garmin eTrex) were recorded for each prey species encountered. The sighting

distance and angles for animals occurring in clusters were recorded to the center of the cluster.

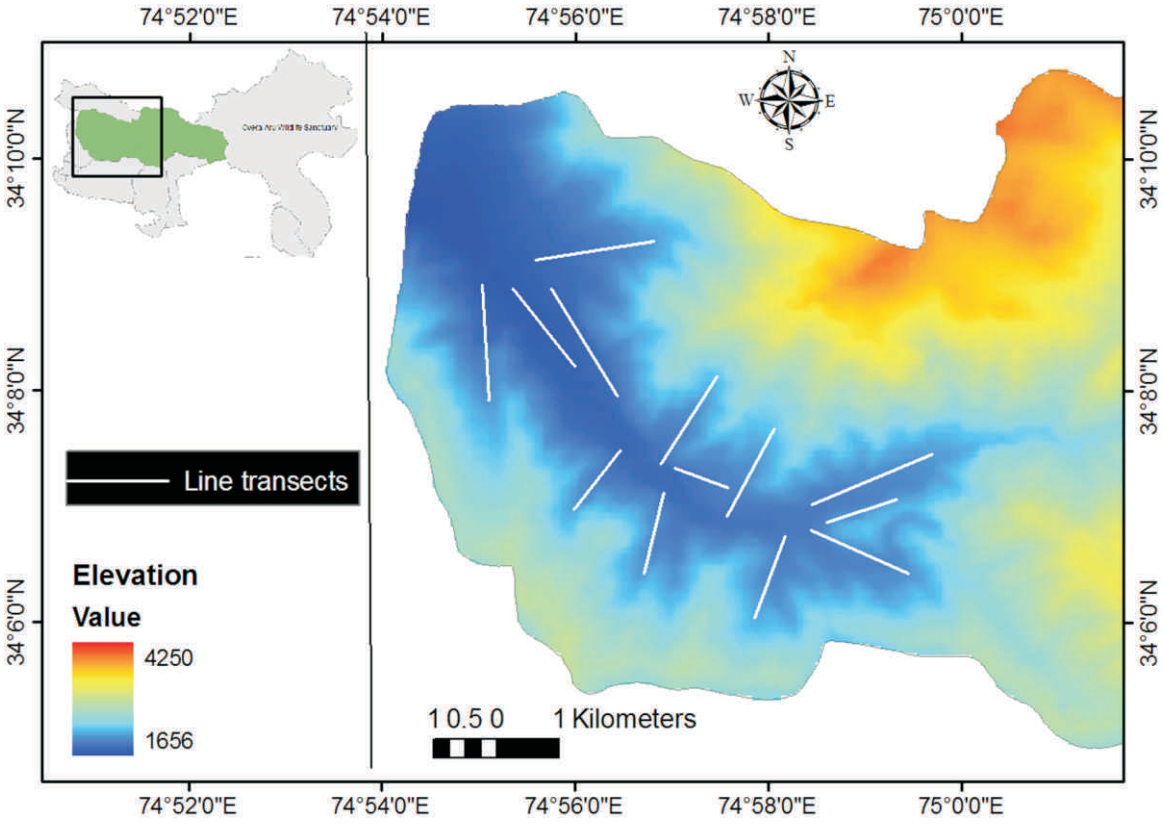

Fig. 3.1 *Location of line transects in Dachigam National Park*

Density of rodents was estimated using live trapping at six different sites in the study area. Sherman live traps (n = 49; each with dimensions 5 cm x 6.5 cm x 16.5 cm) were used for 7 consecutive trap nights at each site in all the four seasons. Total sampling period amounted to 2058 trap nights per season. At each site, traps were placed in a concentric web design with a radius of 60 m covering an area of 1.1 hectare (Fig. 3.2). Each trap station was established 10 m apart in the sampling area. Peanut butter was used to attract rodents to traps. Traps were set in the evening and checked for animals after sunrise the very next morning. The animals were released at the spot of their capture after marking and recording species.

Table 3.1: *Season wise details of sampling effort*

Season	Total effort (km)
Winter	312.6
Spring	449.4
Summer	416.8
Autumn	320.3
Total	**1499.1**

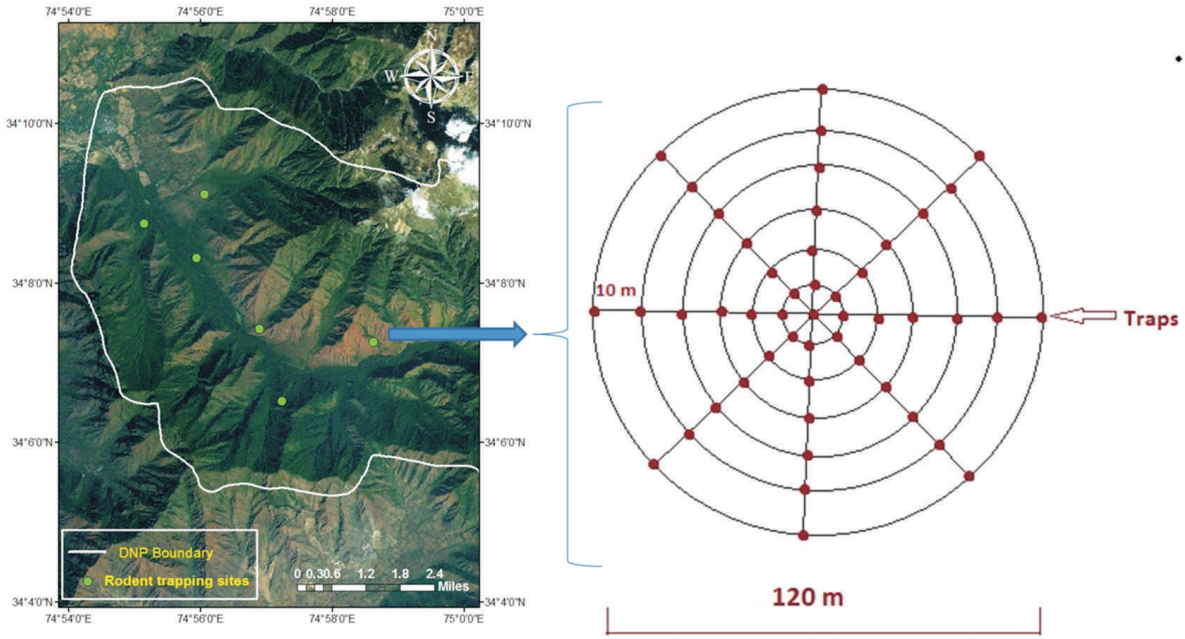

Fig. 3.2: *Locations of Sherman traps placed in a web design*

Prey density estimation

Data was analyzed using program DISTANCE version 6.0 to estimate population densities of langur, hangul and rodents in different seasons. Prior to generating final results, an exploratory analyses of the distribution of the distances was done on data and plotting the resulting histograms in program DISTANCE (Buckland et al., 2001) to detect for any evidence of evasive movement, 'rounding' and 'heaping' of data and to truncate outlier observations, if necessary, for improving model fitting (Jathanna et al., 2003; Edgaonkar, 2008). An appropriate model (the best key function- with the appropriate adjustment term) was judged using Akiake's Information Criteria (AIC) values provided that the p-value for the chi-square goodness of fit for the model was non significant (Burnham and Anderson, 2002). Parameters such as encounter rate (n/L), strip width (ESW), average probability of detection (p), cluster density (DS), cluster size and prey density (D) were also estimated using program DISTANCE (Burnham et al., 1980; Buckland et al., 1993). Density estimates are presented on seasonal basis for langur, hangul and rodents.

The biomass (kg/km^2) of each prey species was calculated by multiplying the mean individual density (D) by its average estimated unit weight (Wegge et al., 2009). The average body weights of prey species were taken from published references (Hayward, 2006; Macdonald, 2001). Biomass availability was estimated for all the four seasons in the study area from year 2011-2013.

Food habits of leopard

A widely used field technique for understanding predator diets is the identification of recognizable parts of prey that have passed through their digestive systems by comparing them with reference collections of potential food items (Koppikar & Sabnis, 1976; Putman, 1984). Dietary profile of leopard was determined by identifying prey remains in the scats as scat analysis technique is advantageous over gut content analysis, direct observation of feeding or kill monitoring as it is easy to conduct, less time consuming and non-invasive.

Scat analysis is a non-destructive tool for examining the diets of carnivore species (Bailey, 1993; Mukherjee et al., 1994; Karanth and Sunquist, 1995; Grassman, 1999; Sankar and Johnsingh, 2002; Edgaonkar and Chelam, 2002; Edgaonkar, 2008).

Scat sample collection

The scat samples were collected systematically as well as opportunistically along trails and roads in Dachigam National Park. Systematic scat collection was done in 19 trails or roads with length ranging from 1.5 to 6.5 km. We also collected scats by following GPS-collared leopards in the area. Leopard scats were identified from other coexisting carnivore species based on their size, shape and adjacent signs of leopard presence (tracks or scrapes).

The location, date, approximate age, associated marking signs and geographic coordinates were recorded for each scat using handheld eTrex Global Positioning System. These scat samples were preserved in tagged polythene bags, labeled with unique scat IDs and taken to the laboratory for analysis. Reference samples of potential wild and domestic prey species were prepared from hair samples of known species obtained from dead animal from the field; and domestic animals from villages around the Dachigam. In order to prepare good quality reference slides, the hairs were cleaned with water followed by ether-alcohol mixture and dried on blotting paper. Hair profile, cuticular and medullar slides were prepared according to the methodology of Teerink (1991). Hair samples were examined grossly and microscopically with features such as color, thickness, medullar configuration, and cuticular scale patterns (Brunner and Coman, 1974; Amerasinghe, 1983; Teerink, 1991; Oli, 1993; Mukherjee et al., 1994; De Marinis and Asprea, 2006).

Scat analysis

Air- dried scats were taken to the laboratory of Wildlife Institute of India, Dehradun. In the lab, all scats were oven dried at 60^{0}C (Sankar and Johnsingh, 2002) for 48 hours, subsequently broken and washed through 1 - 2 mm fine nylon sieve and prey remains such as hairs, bones, hooves, teeth, scales, claws, quills, etc. were separated for identification of prey eaten by leopards (Grobler and Wilson, 1972; Mukherjee et al., 1994; Henschel and Ray, 2003). The sieved prey remains, grass and soil were sun dried in paper bags for 3-4 days to avoid fungal growth. The dried scat samples were then labeled and stored in airtight bags. Following Mukherjee et al. (1994), 20 hair samples randomly selected from each scat sample were then mounted on glass slide using a DPX mountant and examined under microscope with 100X and 400X resolutions.

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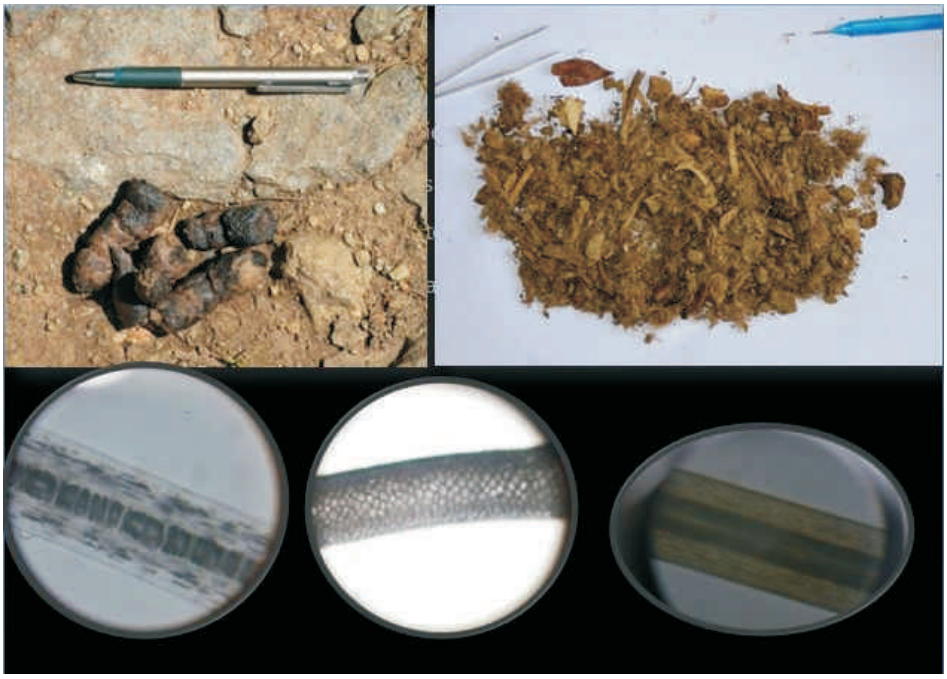

Prey species were identified by comparing key features such as general appearance, color, pigment, length, width, medullary width and cuticular patterns with reference hair (Mukherjee et al., 1994; Bonnin, 2008). Rodents and bird taxa were not identified to species level.

Sample size adequacy

Sample adequacy analysis was carried out to ensure sufficiency of collected scat samples for each season following Mukherjee at al., (1994). Minimum sample adequacy of scats to study food habits of leopard for each season was calculated by selecting random sets of five scats each until all scats within a season were analyzed. This was plotted cumulatively to reach an asymptote which was considered sufficient to quantify the diet of leopard.

Frequency of occurrence of prey

We presented diet data in terms of both frequency of occurrence (proportion of scats containing each food items) and relative frequency of each food items (number of times a specific item was found) as a percentage of all items identified (Ackerman et al., 1984). Prior to calculating of frequency of occurrence, scats containing more than one prey item were given equal values by counting each prey items as ½ (or 0.5), if two food items occurred in one scat, and 1/3 (or 0.33), if three species/taxa occurred, and so on (Karanth and Sunquist, 1995). Frequency of different prey species in leopard scats were analyzed separately for all the four seasons of the year.

Prey biomass and numbers

Although frequency of occurrence has been widely used to quantify carnivore diet, however, if the body sizes of different prey items are highly variable this measure can overestimate the presence of small sized prey (Ackerman et al., 1984) and underestimate the presence of large sized mammalian prey (Weaver, 1993). Smaller sized prey species with more surface area in relation to volume produces more scats per unit prey weight consumed and are overestimated in carnivore diets (Floyd et al., 1978; Ackerman et al., 1984). To minimize biases, we estimated relative proportions of biomass consumed by leopard using the correction factor:

$$Y = 1.98 + 0.035\ X$$

developed by Ackerman et al. (1984) from feeding trails on cougar (*Puma concolor*) where Y is the weight (in kg) of the prey consumed per scat and X

is the average live weight of the prey. Estimates of Y is the biomass consumed per collectible scat for a prey species. The relative biomass of each prey species was calculated separately for all four seasons of the year.

Prey selection

In order to estimate prey selection by leopard, Jacobs' selectivity index (Jacobs 1974) was used to measure the preference for hangul, langur and rodents with respect to their available biomass in different seasons. Jacobs' index standardizes the relationship between the relative proportion that each species makes up of the leopard's diet r and prey relative abundance p (i.e. the proportion that each species makes up of the total abundance of all prey species at a site). The formula for Jacobs' index is:

$$D = \frac{(r_i - p_i)}{(r_i + p_i - 2r_ip_i)}$$

Where r_i is the relative biomass proportion of prey species i in the carnivore scats and p_i is the proportion of biomass of the prey species i in the available prey community. The resulting values range from +1 to -1, where +1 indicates maximum preference and -1 indicates maximum avoidance.

Population estimation of leopard

Camera Trapping

The leopard, like other large cats, occurs at low population densities and because of their secretive behavior, it is impractical to count them visually under usual field conditions (Karanth & Nichols, 1998) thereby making non-invasive methods as potential alternate strategies for studying them. Ever since the first use of camera traps method in capture-recapture framework for tiger population estimation in India (Karanth, 1995; Karanth & Nichols, 1998; Karanth & Nichols, 2002; Edgaonkar 2008, Jhala et al. 2008, Harihar et al. 2009, Sharma et al., 2009), it is being used extensively for density estimation of cryptic species, that possess individually unique coat patterns (spot or stripe) such as leopard (Henschel & Ray, 2003; Edgaonkar, 2008; Mondal, 2012), snow leopard (Jackson et al., 2006; McCarthy et al., 2008), Jaguar (Wallace et al., 2003; Foster, 2007) and Leopard cat (Bashir et al. 2013; Selvan et al. 2014), etc. Leopards, like tigers are found to use game trails and roads for their movements (Henschel and Ray, 2003). Therefore, placing camera traps in strategic positions along these travel routes delivers photographic captures of individual leopards using the study area, and while it is highly unlikely that one can capture all individual

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leopards using a certain area, capture probabilities and population sizes can be estimated mathematically if some of the animals can be individually identified and periodically recaptured (White et al., 1982). An important assumption for the application of capture-recapture models is that none of the individuals present has a zero chance of being captured (Karanth and Nichols, 2002) and it is therefore crucial to the sample design that the whole study area is evenly covered with traps, without leaving gaps large enough to contain an individual's movements (Karanth, 1998). The individuals with the smallest home ranges in a population of leopards are adult females and in the Dachigam National Park we recorded smallest home range size of adult female to be of 41.42 km^2 (see results). Another very important assumption pertaining to camera trap surveys is population closure (Ottis et al., 1978). To maintain the demographic closure i.e. no birth, death, immigration or emigration in the study population, we restricted the duration of the camera trapping to 33 days at our study site because in prior studies on large cats it was suggested that trapping periods of 2-3 months would be sufficiently short to assume no population changes occur during the study (Karanth, 1995; Karanth and Nichols, 1998; Silver et al., 2004).

Leopard density estimation

The entire study area was divided into grids of 2x2 km^2. Depending upon the accessibility and rugged terrain 12 pairs of cameras (Cuddeback attack n = 20; Moultrie n = 4) were used during the study period. In each grid a pair of cameras was placed facing each other, with slight offset to prevent mutual flash interference from the opposite camera (Karanth & Nichols 1998, Silver et al. 2004) in order to obtain photographs of both flanks of the animal. Camera traps were placed on the basis of leopard evidence (pugmark, scats) on the road/trails and nallahs. Each camera was placed 1.5 - 4 meters away from the centre of the road/trail and 30 - 45 cm above ground level depending upon suitable tree. Statistical models assume that all the individuals in the population have a non-zero capture probability (Karanth & Nichols, 1998). Therefore, an inter camera distance of 1.5 km to 2.0 km was maintained to maximize the capture rate and to ensure that no individual's home range lies between cameras. The cameras were kept active 24 hour of a day with camera delay time of 60 seconds. The memory cards were marked properly and changed after every check (usually 2-3 days) and the data was downloaded to a storage device.

Analytical method

Population sizes can be estimated statistically if some of the animals are individually identified and periodically recaptured (White et al., 1982). After identification and giving a unique code to each of the photographs of all leopards, left and right flanks were separated and either right or left flank was chosen for further analysis. A so called X-matrix of capture histories for each adult leopard was developed by typing either '1' or '0' depending on if the individual was captured in each occasion or not. In order to deal with the problem of having large number zeros in the data we collapsed 3 successive trap nights (one trap night = 24 h) to one sampling occasion. Thus, a total of 13 sampling occasions (each 72 h) were accounted for during entire camera trapping period. Total trap nights were calculated by number of camera locations multiplied with number of days sampled. We assumed the sampled population was demographically and geographically closed which is essential for population estimation (Ottis et al., 1978). Programme Close Test (Stanley and Richard, 2005) was used to test closure assumption which tests a null model allowing for time-specific variation in capture probabilities (Stanley and Burnham, 1999).

To estimate the population size of leopard program DENSITY 5.0 was used (Efford 2004). The resulting abundance estimates from DENSITY were used to calculate leopard population density in the study area. Density was defined as;

$D = N/A (W)$

Where, N is the leopard abundance and A is the area where the animals were sampled, including a buffer width (W) around this area (Karanth & Nichols 1998). Numerous studies have assessed the most accurate method of calculating this buffer or effectively sampled area (Wilson & Anderson 1985, Karanth & Nichols 1998, Silver et al. 2004, Soisalo & Cavalcanti 2006, Balme 2009a). As the area demarked by the trapping grid of the camera layout - or the outer perimeter (or polygon) - is not necessarily the entire area in which the sampled animals range (Otis et al. 1978, White et al. 1982), a boundary strip is usually added to the polygon and is defined by the outermost trap sites (Karanth & Nichols 1998). The methods involved in measuring these buffers are: (a) Mean Maximum Distance Moved (MMDM) by individuals photographed on more than one occasion, at more than one camera trap, during the camera survey; (b) halving this distance i.e. Half Mean Maximum Distance Moved

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(HMMDM or ½ MMDM); and (c) Home Range Radius. The density estimates generated from MMDM and HRR buffers are considered to be precise in comparison to ½ MMDM which produce overestimated densities (Sharma et al., 2009).

Ranging and movement pattern

The home range of animal can be defined as the area traversed by the animal in its normal activities of gathering food, caring for young and mating (Burt 1943). The range must satisfy the energy needs of the animal (Gittleman & Harvey 1982) and non-uniform use of land provides information about the distribution, importance and accessibility of important resources such as food (Henschel 1986). The size of home ranges of carnivores are influenced by the food availability, body mass and population density (Gittleman & Harvey, 1982; Benson, Chamberlain & Leopold 2006). Thus, larger bodied animals need larger home ranges to meet metabolic needs (McNab 1963). Leopard is one such large cat which because of cryptic nature and high adaptability can survive in a variety of habitats and environmental conditions. But still this species though, having being widest distribution range amongst large felids, is amongst the least studied species.

To study the ranging pattern of the leopards in the Dachigam National Park three leopards were collared during the study period. Leopards were captured using cages with drop door mechanism. Trapped leopards were then chemically immobilised by the wildlife veterinarian using a combination of ketamine and xylazine drugs. After taking morphometric measurements of the individuals, the leopards were then fitted with Vectronics GPS collars with UHF ground download facility provided with VHF option, and left where they were trapped to fully recover from the drug effect.

Home range estimation

The home range analysis was done using ArcView 3.2 and ArcGIS 9.3. We used minimum convex polygon (100% MCP; Mohr 1947) and 90% fixed kernels as home range estimators. MCPs are used to directly compare home ranges with other studies while fixed kernels (50% and 90%) are used to see core activity centers where intensity of space utilization is represented by these kernels.

Leopard Ecology Project

RESULTS

4

Nazir Ahmad

Prey abundance

In total 5 large prey species were detected on line transects. They include three ungulates (hangul, musk deer, and wild boar) and two primate species (Himalayan grey langur and rhesus macaque). We estimated density of hangul and langur among large prey and rodents among small prey on seasonal basis. Other species were less common in the area and only a few sightings were recorded during our study, hence their densities could not be calculated. In total 170 groups of langur comprising of 2679 individuals and 206 groups of hangul comprising of 829 individuals were sighted in different seasons in the study area. Overall density (±SE) of langur (Fig. 4.1) was estimated to be higher (16.32 ± 1.87/km^2) than density of hangul (5.11 ± 0.51/km^2) (Fig. 4.2) in the study area.

Seasonal variation

Density of langur was higher than hangul in all the four seasons. Both species showed seasonal

variation in densities. Langur density was highest (22.05 ± 5.12/km²) in winter season and lowest (9.35 ± 3.03/km²) in summer season (Table 4.1). While as hangul density was observed to be highest (9.51 ± 1.71/km²) in spring season and lowest (2.31 ± 0.51/km²) in summer season. Density, average group size, encounter rate and other parameters of hangul in different seasons are given in (Table 4.2). Effective strip width (ESW) varied from season to season as well as with species. For hangul ESW was highest in winter and lowest in summer. While in case of langur it was highest in winter and lowest in autumn season. Cluster size for the best selected model for langur was highest in summer season (18.65 ± 3.12) and lowest in autumn season (12.44 ± 1.24) (Table 4.1). In case of hangul cluster size was lowest in summer season (1.75 ± 0.16) and highest in winter season (4.44 ± 0.49) (Table 4.2).

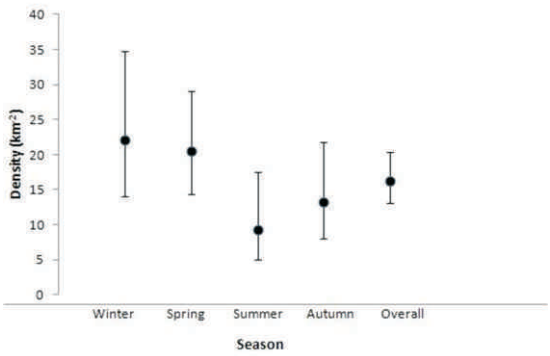

Fig. 4.1: *Seasonal variation in individual density (km^{-2}) of Himalayan grey langur with 95% confidence intervals.*

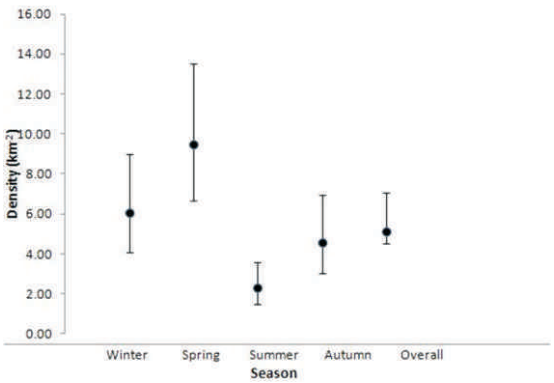

Fig. 4.2: *Seasonal variation in individual density (km^{-2}) of Hangul with 95% confidence intervals.*

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Rodent density

In total 576 individuals of rodents were captured by Sherman trapping, during our study. Rodent density estimated by program 'Distance' was found to be highest in summer season (2014 ± 830.71/km²) followed by spring, autumn and winter (1172.6 ± 442.74/km²). Effective detection radius (EDR) also varied with seasons, highest being in winter (28.73 m) and lowest in summer (25.47 m) (Table 4.3).

Prey biomass estimation

Overall prey biomass estimates showed that hangul formed bulk of the prey in all seasons except summer season. Hangul biomass varied from 254.1 kg/km² in summer to 1046.1 kg/km² in winter, followed by biomass of rodents which was highest in summer season (402.90 kg/km²) and lowest in winter season (234kg/km²). Langur contributed least to biomass availability in all the four seasons as it varied from 93.50 kg/km² to 220.50 kg/km² (Table 4.4). Fig. 4.3 gives relative biomass availability in terms of langur, hangul and rodents, in Dachigam National Park.

Table 4.1: *Estimation of Individual Density, Group density, Effective strip width, Average Cluster Size and Encounter Rate (ER; n/km) of Himalayan grey langur in different seasons inside Dachigam National Park, Srinagar. Parameter estimates and associated measures of variance were based on the model with least Akaike's Information Criteria (AIC) value.*

Parameters	Winter	Spring	Summer	Autumn	Over all
Effort (km)	312.6	449.4	416.8	320.3	1499.1
No. of sightings	57	61	23	29	170
Individual Density (No. of individual/km^2)	22.05	20.48	9.35	13.29	16.32
Standard Error	5.12	3.67	3.03	3.35	1.87
Percent CV	23.22	17.96	32.47	25.27	11.49
Group Density (No. of Groups/km^2)	1.21	1.3	0.5	1.06	0.99
Standard Error	0.18	0.19	0.13	0.24	0.08
Percent CV	14.94	14.81	27.82	23.2	8.97
Effective Strip Width (m)	72.42	53.34	54.98	42.37	56.81
Standard Error	7.42	5.26	10.81	6.75	3.35
Percent CV	10.26	9.87	19.68	15.95	5.91
Average Group Size	18.154	15.66	18.65	12.44	16.43
Standard Error	3.22	1.59	3.12	1.24	1.17
Encounter Rate (No. seen/km Walk)	0.17	0.13	0.05	0.09	0.11
Percent CV	10.86	11.04	19.67	16.85	6.76
Detection Probability	0.45	0.44	0.36	0.32	0.28

Table 4.2: *Estimation of Individual Density, Group density, Effective strip width, Average Cluster Size and Encounter Rate (ER / km) of Hangul in different seasons inside Dachigam National Park, Srinagar. Parameter estimates and associated measures of variance were based on the model with least Akaike's Information Criteria (AIC) value.*

Parameters	Winter	Spring	Summer	Autumn	Over all
Effort (km)	312.6	449.4	416.8	320.3	1499.1
No. of sightings	49	76	36	45	206
Individual Density (No. of animal/km^2)	6.05	9.51	2.31	4.59	5.11
Standard Error	1.22	1.71	0.51	0.97	0.51
Percent CV	20.24	18.06	22.16	21.15	10.12
Group Density (No. Groups/km^2)	1.36	2.29	1.32	1.32	1.49
Standard Error	0.23	0.33	0.26	0.22	0.11
Percent CV	16.94	14.40	20.00	17.03	7.99
Effective Strip Width (m)	53.99	39.14	32.60	52.81	45.02
Standard Error	6.26	4.00	4.22	5.95	2.36
Percent CV	11.60	10.22	12.97	11.28	5.23
Average Group Size	4.44	4.14	1.75	3.45	3.41
Standard Error	0.49	0.45	0.16	0.43	0.21
Encounter Rate (No. seen/km walk)	0.14	0.17	0.08	0.14	0.13
Percent CV	12.35	10.14	15.23	12.76	6.03
Detection Probability	0.49	0.32	0.46	0.50	0.40

Table 4.3: *Estimation of Individual Density and Effective detection radius of rodents in different seasons inside Dachigam National Park, Srinagar. Parameter estimates and associated measures of variance were based on the model with least Akaike's Information Criteria (AIC) value.*

Parameter	Winter	Spring	Summer	Autumn
No. of captures	79	94	103	86
Individual Density (No. of Animal/km²)	1172.6	1588	2014.5	1302
Standard Error	442.74	626.46	830.71	501.44
Percent CV	37.76	39.45	41.24	38.51
Effective Detection Radius (m)	28.73	26.42	25.47	27.38
Standard Error	3.58	2.68	2.30	3.05
Percent CV	12.48	10.17	9.06	11.17
Probability of greater chi square value, P	0.87	0.79	0.6	0.87
Detection Probability	0.22	0.19	0.17	0.2

Table 4.4: *Seasonal biomass estimates of available prey in Dachigam National Park.*

	Hangul		Langur		Small Rodents	
Season	**Density ± SE (km-²)**	**Biomass (kg/km²)**	**Density ± SE (km⁻²)**	**Biomass (kg/km²)**	**Density ± SE (km⁻²)**	**Biomass (kg/km²)**
Winter	6.05 ± 1.22	665.5	22.05 ± 5.12	220.50	1172.6 ± 442.74	234.52
Spring	9.51 ± 1.71	1046.1	20.49 ± 3.67	204.90	1588.0 ± 626.46	317.60
Summer	2.31 ± 0.51	254.1	09.35 ± 3.03	093.50	2014.5 ± 830.71	402.90
Autumn	4.59 ± 0.97	504.9	13.29 ± 3.35	132.90	1302.2 ± 501.44	260.44

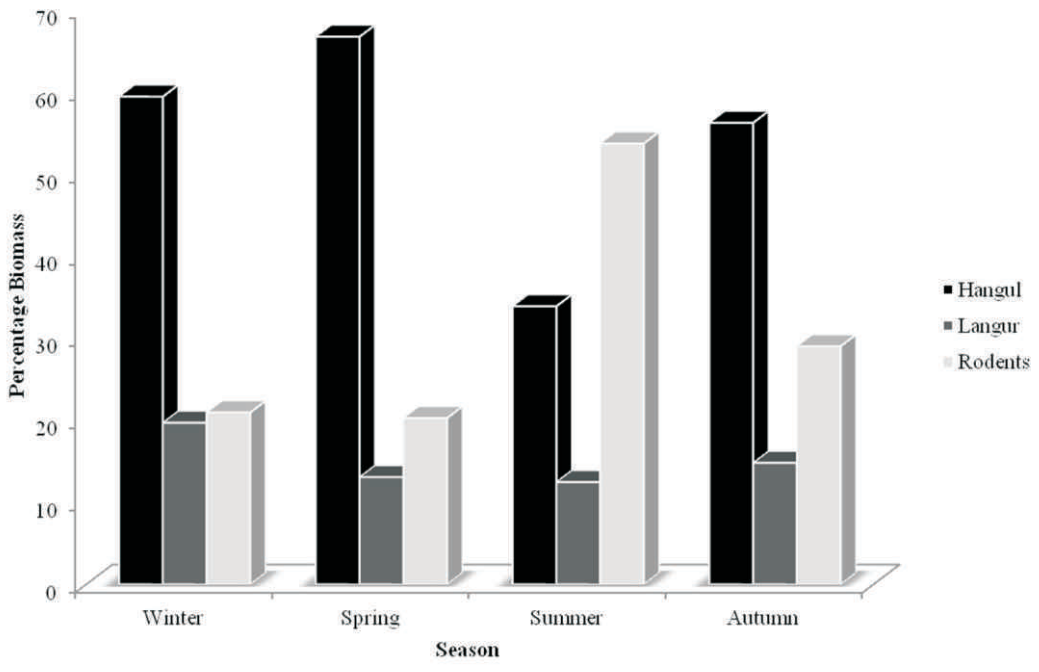

Fig. 4.3: *Proportions of the standing biomass of available prey species in Dachigam National Park.*

Food habits of leopard

Overall 714 leopard scats were collected during our study period among which 189 scats were collected in winter season, 284 in spring, 117 in summer and 124 scats in autumn season. We identified 17 different prey items from their remains in scats during our study. Number of prey items per scat showed good seasonal variation. In winter season 78.83% analyzed scats contained only a single prey item, 19.04% contained two prey items while as 2.11% contained three prey items. In summer season the percentage of scats containing single prey item decreased to 53.84% and percentage of scats containing double and triple prey items increased to 40.17% and 5.98% respectively (Fig. 4.4)

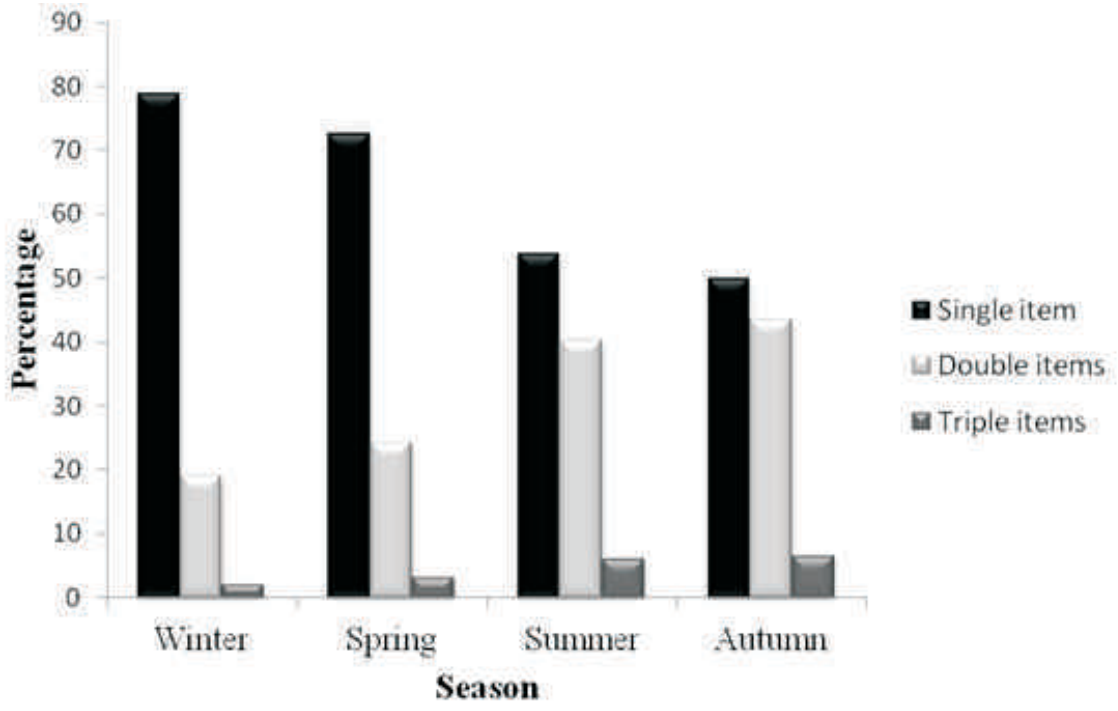

Fig. 4.4: *Number of prey items detected in leopard scat in different seasons (n = 714) from year 2011-2013.*

Frequency of occurrence of prey

Frequency of occurrence and percentage occurrence of prey remains in leopard scats from year 2011 to 2013 in the study area are given in Table 4.5. Overall for the entire study period small rodents contributed maximum (48.05%) in terms of percent frequency of occurrence to the leopard diet followed by langur (14.04%), sheep (Ovis aries), goat (Capra aegagrus hircus) and dog (Canis lupus familiaris). Hangul contributed 2.05% while serow (0.20%) and rhesus macaque (0.10%) contributed least to the diet of leopard. Among cattle species only remains of cow (Bos primigenius) were found in 3 leopard scats hence contributing 0.31% to leopard diet. Minimum sample size required to study food habits of leopard varied from 66 to 86 scat samples in different seasons (Fig. 4.5). Scat samples collected in all the four seasons were sufficient to document prey selection pattern of leopard.

Table 4.5: *Frequency of occurrence and proportion of biomass consumed by leopard for different prey species (2011-2013).*

Species	Count	Freq. of occurrence	% Occurrence	% Biomass consumed
Small Rodents	469	65.69	48.05	43.71
Langur	137	19.19	14.04	14.97
Sheep	74	10.36	7.58	9.30
Goat	67	9.38	6.86	8.42
Dog	59	8.26	6.05	6.64
Grass	39	5.46	4.00	--
Bear	24	3.36	2.46	5.38
Hangul	20	2.80	2.05	5.47
Arthropods	20	2.80	2.05	--
Bird	18	2.52	1.84	1.70
Jackal	15	2.10	1.54	1.64
Porcupine	13	1.82	1.33	1.46
Unidentified	10	1.40	1.02	--
Fish scales	5	0.70	0.51	--
Cow	3	0.42	0.31	0.77
Serow	2	0.28	0.20	0.43
Rhesus macaque	1	0.14	0.10	0.10

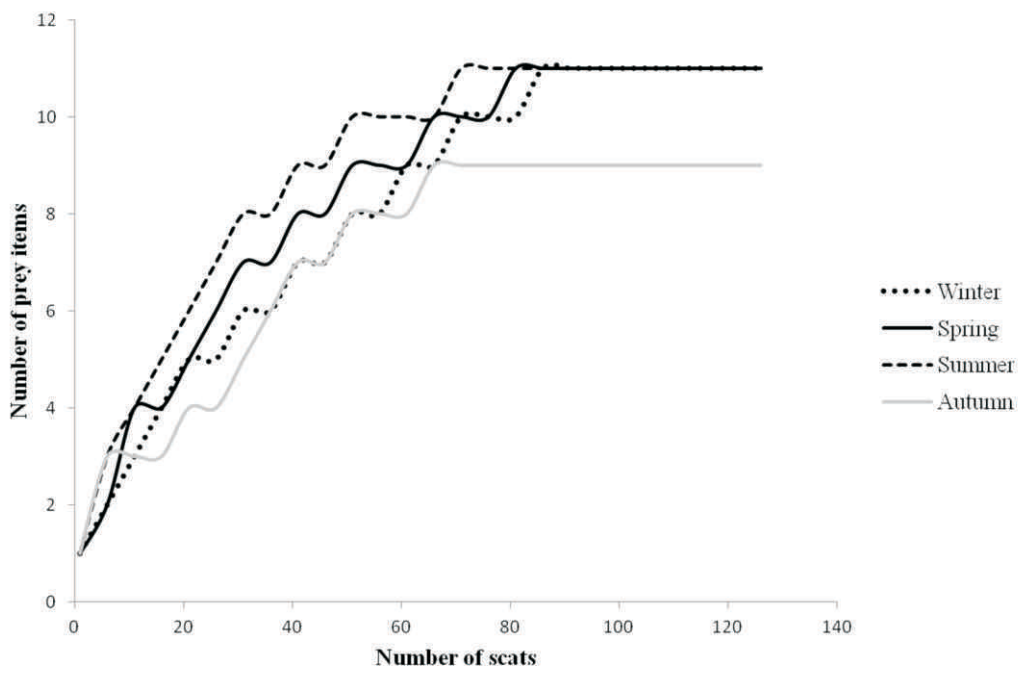

Fig. 4.5: *Relationship between number of scats analyzed and number of prey species found in leopard diet.*

Seasonal variation

Contribution of different prey items in leopard diet changed with seasons. Small rodents contributed highest to leopard diet in summer season both in terms of percent occurrence (55.63%) as well as percent biomass consumed (53.77%) while as their contribution decreased in winter season. While in case of large prey, consumption was high in winter season when langur and hangul contributed 19.28 %

and 8.57% respectively in terms of biomass. Consumption of large prey decreased in summer season as langur and hangul composed only 10.83% and 1.59% of biomass consumed by leopard respectively. Tables (4.6 - 4.9) gives a detailed account of frequency of occurrence, percent biomass taken and number of prey individuals taken by leopard in different seasons.

Table 4.6: *Percentage frequency of occurrence (FOO) and proportion of biomass consumed and number of individual consumed by leopard for different prey species in winter season (2011-2013).*

Animal	Wt (kg)	FOO (%)	% Relative estimated bulk	Collectable Scats/Kill	Biomass/100 Scats	% Biomass eaten	No. of Individuals eaten/100 Scats
Small Rodents	0.2	38.20	40.53	0.10	80.53	32.52	402.63
Langur	10	19.31	20.49	4.29	47.73	19.28	4.77
Dog	12	8.85	9.39	5.00	22.53	9.10	1.88
Goat	20	7.73	8.20	7.46	21.98	8.88	1.10
Sheep	20	6.87	7.29	7.46	19.53	7.89	0.98
Hangul	110	3.43	3.64	18.87	21.21	8.57	0.19
Bear	80	3.00	3.18	16.74	15.21	6.14	0.19
Birds	0.85	3.00	3.18	0.42	6.40	2.58	7.53
Jackal	10	2.15	2.28	4.29	5.31	2.15	0.53
Cow	100	0.86	0.91	18.25	5.00	2.02	0.05
Porcupine	12	0.86	0.91	5.00	2.19	0.88	0.18
Rhesus macaque	7	0.00	0.00	3.15	0.00	0.00	0.00
Serow	75	0.00	0.00	16.29	0.00	0.00	0.00

Table 4.7: *Percentage frequency of occurrence (FOO) and proportion of biomass consumed and number of individual consumed by leopard for different prey species in spring season (2011-2013).*

Animal	Wt (kg)	FOO (%)	% Relative estimated bulk	Collectable Scats/Kill	Biomass/100 Scats	% Biomass eaten	No. of Individuals eaten/100 Scats
Small Rodents	0.2	50.94	55.42	0.10	110.11	46.55	550.55
Langur	10	14.02	15.25	4.29	35.53	15.02	3.55
Sheep	20	7.28	7.92	7.46	21.22	8.97	1.06
Goat	20	5.12	5.57	7.46	14.93	6.31	0.75
Dog	12	4.31	4.69	5.00	11.25	4.76	0.94
Bear	80	2.70	2.94	16.74	14.04	5.94	0.18
Hangul	110	2.43	2.64	18.87	15.38	6.50	0.14
Jackal	10	2.16	2.35	4.29	5.47	2.31	0.55
Porcupine	12	1.35	1.47	5.00	3.52	1.49	0.29
Bird	0.85	1.08	1.17	0.42	2.36	1.00	2.78
Serow	75	0.54	0.59	16.29	2.70	1.14	0.04
Cow	100	0.00	0.00	18.25	0.00	0.00	0.00
Rhesus macaque	7	0.00	0.00	3.15	0.00	0.00	0.00

Table 4.8: *Percentage frequency of occurrence (FOO), proportion of biomass consumed and number of individual consumed by leopard for different prey species in summer season (2011-2013).*

Animal	Wt (kg)	FOO (%)	% Relative estimated bulk	Collectable Scats/Kill	Biomass/100 Scats	% Biomass eaten	No. of Individuals eaten/100 Scats
Small Rodents	0.2	55.62	61.11	0.10	121.43	53.77	607.17
Langur	10	9.55	10.49	4.29	24.45	10.83	2.44
Sheep	20	7.87	8.65	7.46	23.18	10.26	1.16
Goat	20	6.74	7.41	7.46	19.85	8.79	0.99
Dog	12	3.93	4.32	5.00	10.36	4.59	0.86
Bear	80	2.25	2.47	16.74	11.82	5.23	0.15
Porcupine	12	1.69	1.86	5.00	4.46	1.97	0.37
Bird	0.85	1.12	1.23	0.42	2.47	1.10	2.91
Jackal	10	1.12	1.23	4.29	2.87	1.27	0.29
Hangul	110	0.56	0.62	18.87	3.59	1.59	0.03
Rhesus macaque	7	0.56	0.62	3.15	1.37	0.61	0.20
Cow	100	0.00	0.00	18.25	0.00	0.00	0.00
Serow	75	0.00	0.00	16.29	0.00	0.00	0.00

Table 4.9: *Percentage frequency of occurrence (FOO), proportion of biomass consumed and number of individual consumed by leopard for different prey species in autumn season (2011-2013).*

Animal	Wt (kg)	FOO (%)	% Relative estimated bulk	Collectable Scats/Kill	Biomass/100 Scats	% Biomass eaten	No. of Individuals eaten/100 Scats
Small Rodent	0.2	47.42	51.68	0.10	102.68	44.64	513.42
Langur	10	11.86	12.93	4.29	30.12	13.09	3.01
Goat	20	9.28	10.11	7.46	27.10	11.78	1.36
Sheep	20	8.76	9.55	7.46	25.59	11.12	1.28
Dog	12	7.73	8.42	5.00	20.22	8.79	1.68
Bird	0.85	2.58	2.81	0.42	5.65	2.46	6.65
Bear	80	1.55	1.69	16.74	8.07	3.51	0.10
Porcupine	12	1.55	1.69	5.00	4.05	1.76	0.34
Hangul	110	1.03	1.12	18.87	6.54	2.84	0.06
Cow	100	0.00	0.00	18.25	0.00	0.00	0.00
Jackal	10	0.00	0.00	4.29	0.00	0.00	0.00
Rhesus macaque	7	0.00	0.00	3.15	0.00	0.00	0.00
Serow	75	0.00	0.00	16.29	0.00	0.00	0.00

Prey selection

Jacobs' index was calculated from biomass availability and biomass consumption for hangul, langur and small rodents. It indicated that small rodents and langur were consumed more than their availability and hangul was consumed less than availability in all the four seasons (Fig 4.6).

Preference of hangul was slightly higher (-0.79) during winter season as compared to summer season (-0.90). The index of prey selection by leopard at individual species level was in the following order: rodents > langur > hangul (Fig 4.6).

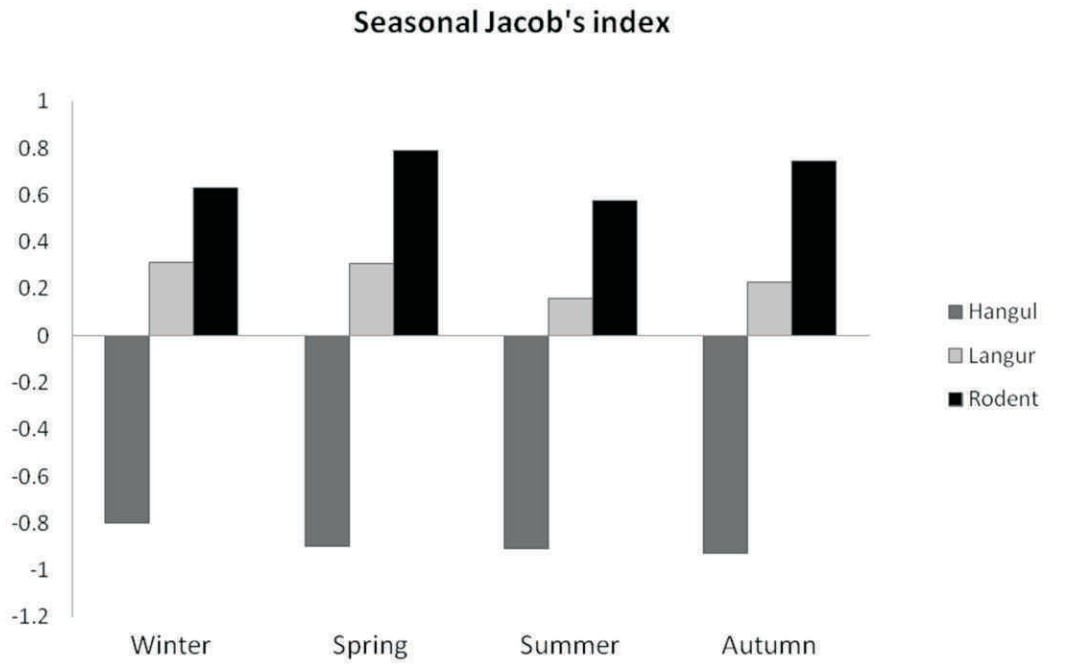

Fig. 4.6: *Prey selection by leopard in the study area using Jacobs' index of selectivity based on availability of individuals and utilization as shown by scat analysis in different seasons.*

Population estimation of leopard

A total of 396 trap nights resulted in a total of 14 leopard photographs with 3 individual leopards. Out of these 14 photographs only one could not be used for analysis because of its poor quality. Amongst the three individuals 2 males and 1 female was photo-captured. Test for population closure was not significant for leopard, indicating that the assumption of demographic closure was not violated during the study period ($\chi^2 = 2.59$, $p = 0.62$).

Model selection and density estimation

The best-fitting model selected by CAPTURE, called from within the software DENSITY, was the Null (M_0) model (criterion score of 1.00) which assumed constant capture probability over all occasions and animals (White et al. 1982, Trolle & Kery 2003). The M_0 model resulted in a population size of 3.00 ± 0.57 and an estimated capture probability of 0.179. The second best performing model selected by CAPTURE was the Heterogeneity (M_h) model (criterion score of 0.88) which assumed that each individual had its own capture probability and that this remained constant over the sampling period (Karanth & Nichols 1998). The estimated leopard population size for this model using the jackknife estimator was 3.92 ± 1.39, with a capture probability per sampling occasion of 0.137. The density estimates generated by MMDM (1.53 ± 0.33 100 km^{-2}) and HRR (1.61 ± 0.35 100 km^{-2}) buffering methods were almost similar for the M_0 model similarly, in the M_h model the MMDM (2.01 ± 1.00 100 km^{-2}) density was slightly lower than the HRR density (2.11 ± 1.06 100 km^{-2}). In both the models 1/2MMDM method overestimated the density values (Table 4.10). Although, the Null (M_0) model was selected based on highest criterion score, we selected the Heterogeneity (M_h) model because leopards are territorial animals and it accounts for heterogeneous capture probabilities between individuals. It is also known to be a robust model (Otis et al., 1978) and thus, used the jackknife estimator for the density estimation (Burnham &

Overton 1978, Otis et al., 1978). The density estimate produced by HHR (2.11 ± 1.06 100 km^{-2}) was selected as density of the leopard in the study area. The mean maximum distance moved by the leopards and the average home range radius was 5.00 ± 1.36 km and 4.80 ± 1.38 km. The relative abundance index of the leopard in the sampling duration turned out to be 3.5 per 100 trap nights. The maximum photo-capture rate of leopard was found during evening hours between 18:00 and 21:00 (Fig.4.7).

Table 4.10: *Density estimates for leopard using different methods in Dachigam National Park*

Best Model	Mt+1	P hat	N ± SE	95% CI	Method	ETA (km^{-2})	Density ± SE (100 km^{-2})
M_0 (Null)	3	0.179	3.00 ± 0.57	L = 3.00	MMDM	195	1.53 ± 0.33
				U = 5.55	1/2MMDM	87	3.44 ± 0.74
					HRR	186	1.61 ± 0.35
M_h (Jackknife)	3	0.137	3.92 ± 1.39	L = 3.11	MMDM	195	2.01 ± 1.00
				U = 10.81	1/2MMDM	87	4.45 ± 2.26
					HRR	186	2.11 ± 1.06

Mt+1 – No. of individuals caught, N – Population size, P hat – Capture probability per occasion, SE – Standard error, CI – 95% Confidence Interval, MMDM – Mean Maximum Distance Moved, 1/2MMDM – Half Mean Maximum Distance Moved, HRR – Home Range Radius averaged from home range (100%MCP) estimates of three collared individuals, ETA – Effective Trapping Area

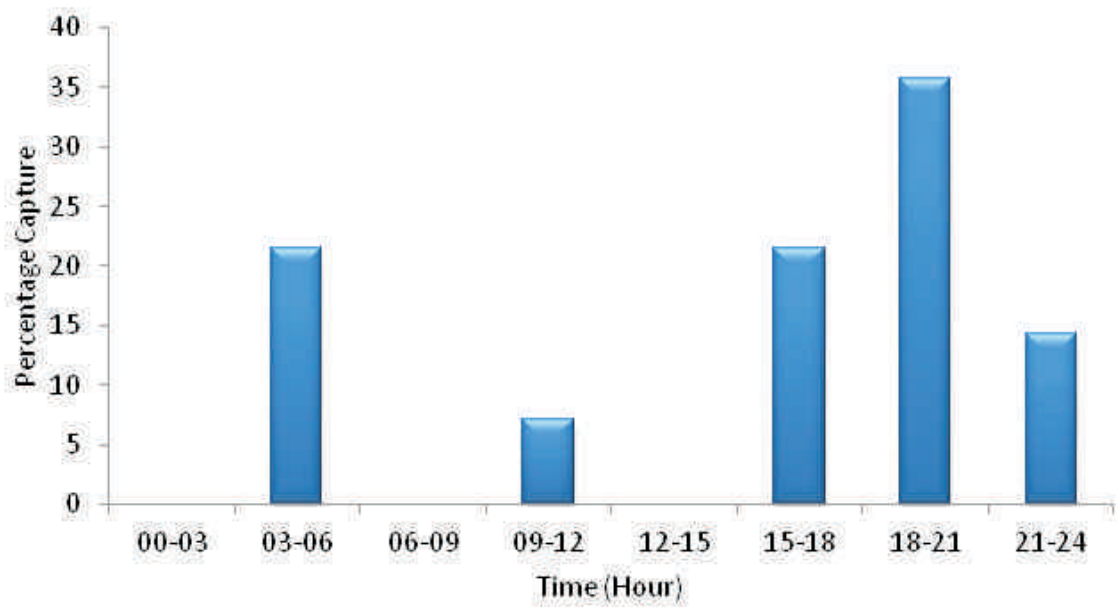

Fig. 4.7: *Activity pattern of leopard based on camera trap photo captures in Dachigam National Park.*

Ranging and movement pattern

A total of three adult leopards (2 females and 1 male) were captured using drop door mechanism cages from March 2012 to July 2013 with an average capturing effort of 150 trap days per individual (Table 4.11). Details pertaining to morphological measurements taken and are presented in Table 4.12. The collars deployed on the leopards worked well with variable success rates

(Table 4.13). The collars were set to take 5-7 GPS fixes in 24 hours except the collar F71 where it was set to fix every 2 hours. But this female lost contact after 20 days and only 170 locations could be generated successfully through this individual (Table 4.13).

Minimum convex polygon (MCP) home range

The 100% MCPs are shown in Fig. 4.8 (a-b), the male leopard M73 has the largest home range of ~ 145 km^2 (Fig. 4.8a) which was recorded during the summer season. The maximum home range (100%MCP) of the female F74 was ~ 74 km^2 which was recorded during summer season. The summer home range (100% MCP) of the male was 1.96 times larger than the female leopard. The least home range (~ 41.4 km^2; 100% MCP) came up during the winter season. The increasing trend represented by the ranges (100% MCPs) of this female was winter < spring (48.42 km^2) < autumn (67.9 km^2) < summer (Fig. 4.8b).

Fixed kernel (FK) home range

The fixed kernel home ranges are tabulated in Table 4.14. In Fig. 4.9 (a-c) different FKs namely, 90%, 75% and 50% are compared for number of locations and corresponding home ranges for both the sexes of leopard. The number of locations required to estimate kernel home ranges plotted against home range area flattens off at about 500 GPS fixes for both the male and female leopards. For female - F74, during winter season the 90% and 50% fixed kernel intensity of use areas are just ~ 40 km^2 and ~ 13 km^2, respectively, whereas these sizes get maximised during the summer when 90% fixed kernel area increases to become ~ 62 km^{2}and 50% fixed kernel becomes ~ 16 km^2 (Fig. 4.10a-b). Since, for the male summer data is available only, the 90% fixed kernel area turns out to be ~ 130 km^2 while 50% fixed kernel area is just ~ 37 km^2 (Fig. 4.10a-b). Utilization distribution core areas developed through contour maps are represented by Fig. 4.11(a) and (b) depicting core areas of male M73 and female F74, respectively. The maximum overlap of 44.25% was represented between male and female (M73 – F74) in the 50% fixed kernel core areas (Table 4.15). While minimum overlap in the 50% fixed kernel cores was 13.7% which was observed between the two females (F71 – F74) (Table 4.15).

Daily distance moved

The leopards show large variation in daily distances moved (Fig. 4.12) during the lean season of summer. Daily displacements of the leopards were not normally distributed (Kolmogorov-Smirnov Test) for the male: M73 (D = 0.119, df = 105, p = 0.001), female: F71 (D = 0.191, df = 105, p = 0.000) and female: F74 (D = 0.092, df = 105, p = 0.029). Daily displacement was longer for the male leopard (median displacement = 588 m) than the female leopard (median displacement = 367.44 m) (Table 4.16). On perusal of Table 4.16, it is found that the total distance travelled by the male leopard (398.71 km) was greater than the female leopards: F74 (374.16 km) and F71 (62.91 km). In case of female leopard F74, the median daily distance travelled was highest during the winter season (0.664 km) followed by autumn (0.528 km), spring (0.506 km) and summer (0.367 km) (Table 4.16).

Activity Pattern

Activity data received from collar was analyzed using program *Activity Pattern 1.2.3.*
Each collar measures activity along X and Y axes based on the true acceleration experienced by the collar. Activity is measured four times per second as the difference in acceleration between two consecutive measurements, and is given within a relative range of 0-255. A perusal of Fig. 4.13 (a-c) depicts a bimodal activity patterns across the time periods, for the both the sexes as well as between seasons in case of female leopard – F74 (Fig. 4.13a). On comparison of mean activity between male (M73) and female (F74) leopards it was found that female was more active in comparison to male (Fig. 4.13c).

Table 4.11: *Leopard capturing success using cage traps in Dachigam National Park.*

Months	Capturing Technique	Type	Numbers	Effort (Trap Nights)	Bait Type	Success
May - June 2011	Foot-hold Snares	-	4	120	-	NO
July - August 2011	Drop Door Cage	Mesh	1	25	Dog + Rotten Meat	NO
Feb. - March 2012	Drop Door Cage	Barrel + Mesh	3 (2 Barrel + 1 Mesh)	75	Live Chicken + Dog	YES
April - May 2012	Drop Door Cage	Barrel + Mesh	2 (1 Barrel + 1 Mesh)	50	Live Chicken + Dog	NO (Recapture of first leopardess)
Oct. - Nov. 2012	Drop Door Cage	Barrel + Mesh	2 (1 Barrel + 1 Mesh)	50	Live goat + Chicken	YES
Feb. - April 2013	Drop Door Cage	Mesh + Mesh	2	80	Live goat + Dog	NO
June - July 2013	Drop Door Cage	Mesh + Mesh	2	50	Live goat + Dog	YES

Table 4.12: *Morphometry of the leopards collared in Dachigam National Park.*

Collared animal ID	Date of capture	Sex	Body weight (kg)	Body length (cm)	Tail length (cm)	Total body length (cm)	Neck girth (cm)	Chest girth (cm)	Abdomen girth (cm)	Shoulder height (cm)	Front paw Total Length Total Width (cm)	Rear paw Total Length Total Width (cm)
F 74	18.03.2012	F	39	107	76	183	48	70.6	91.4	61	L = 7.7 W = 7.5	L = 7.9 W = 7.6
F 71	11.11.2012	F	38	91	33	124	50.8	76.2	50.8	63	L = 7.69 W = 6.11	L = 7.9 W = 5.9
M 73	05.07.2013	M	65	105	100	205	52	85	90	65	L = 10.62 W = 8.44	L = 8.38 W = 6.94
F#	25.01.2012	F	41	118	86	204	46	-	75	64	L = 8.3 W = 6.8	L = 7.26 W = 6.24

This female leopard was a conflicting animal captured by the Deptt. of Wildlife Protection, J&K, Staff from a nearby locality. It could not be collared because of severe injury in one of her hind feet.

Table 4.13: Number of GPS locations successfully fixed by the collars and duration of data collection in Dachigam National Park

Collared Animal ID	Date of Deployment	No. of Days	GPS Fix Attempts	Successful Fixes	Success Rate (%)
F 74	18.03.2012	438	2973	2321	78.06
F 71	11.11.2012	20	175	170	97.14
M 73	05.07.2013	78	694	546	78.67

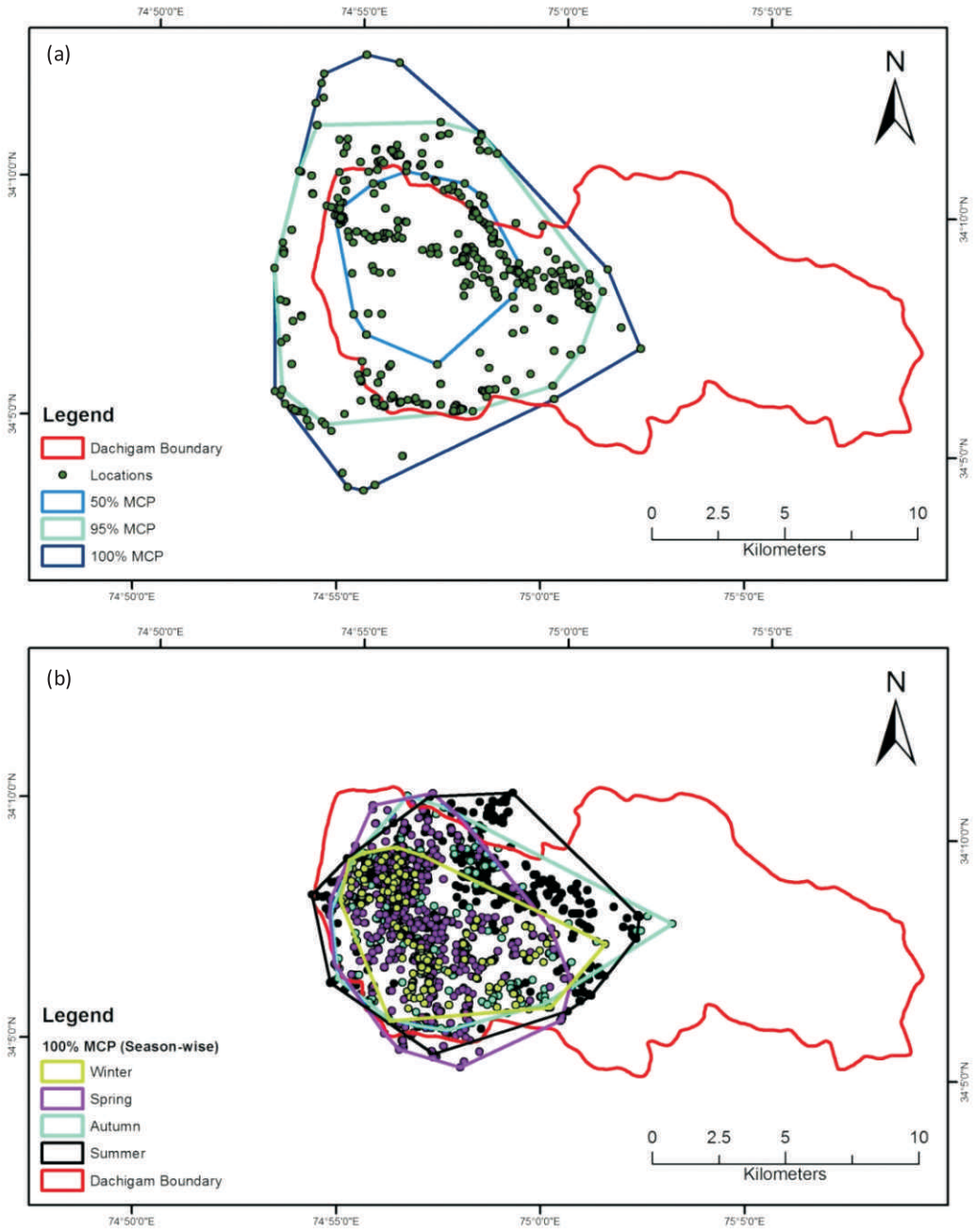

Fig. 4.8: *100% MCP home range of male (a) M73; and (b) seasonal home ranges of the female leopard (F74) in the Dachigam National Park.*

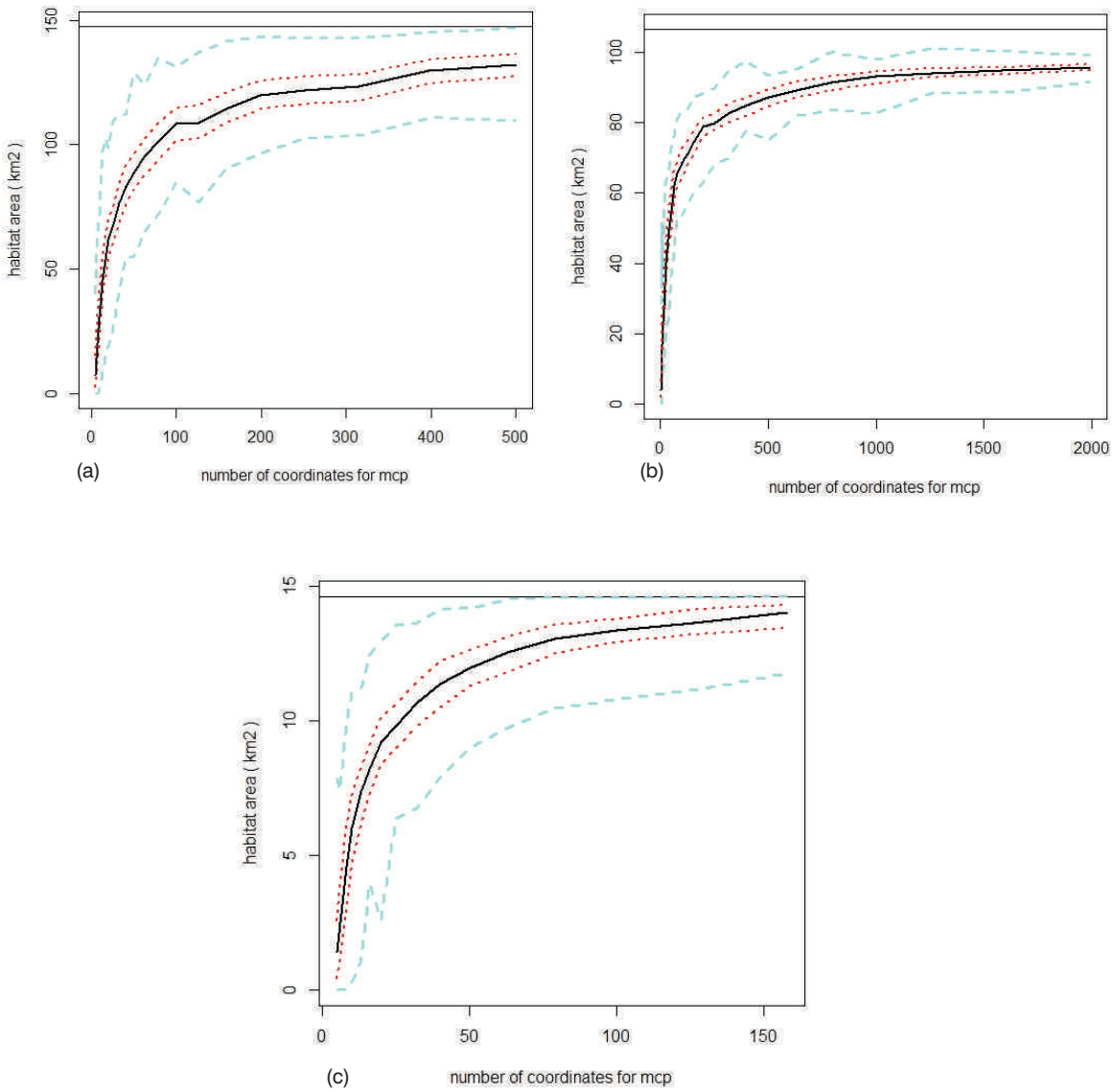

Fig. 4.9 (a-c): *Asymptotes represented by the GPS fixes taken by the collared leopards – (a) male M73, (b) female F74 and (c) female F71. (– – – denotes 100% FK, ····· denotes 75% FK and — denotes 50% FK).*

Table 4.14: *Home Ranges (Fixed Kernel; FK) of the three Collared Leopards (F = Female; M = Male) in Dachigam National Park.*

	90% FK (km^{-2})			75% FK (km^{-2})			50% FK (km^{-2})		
Animal ID	F 71	M 73	F 74	F 71	M 73	F 74	F 71	M 73	F 74
Spring	-	-	43.90			24.65	-	-	10.69
Summer	-	130.03	62.26		78.34	35.75	-	37.97	16.48
Autumn	21.44	-	54.59	13.88		33.07	6.92	-	16.10
Winter	-	-	40.52			25.77	-	-	13.14

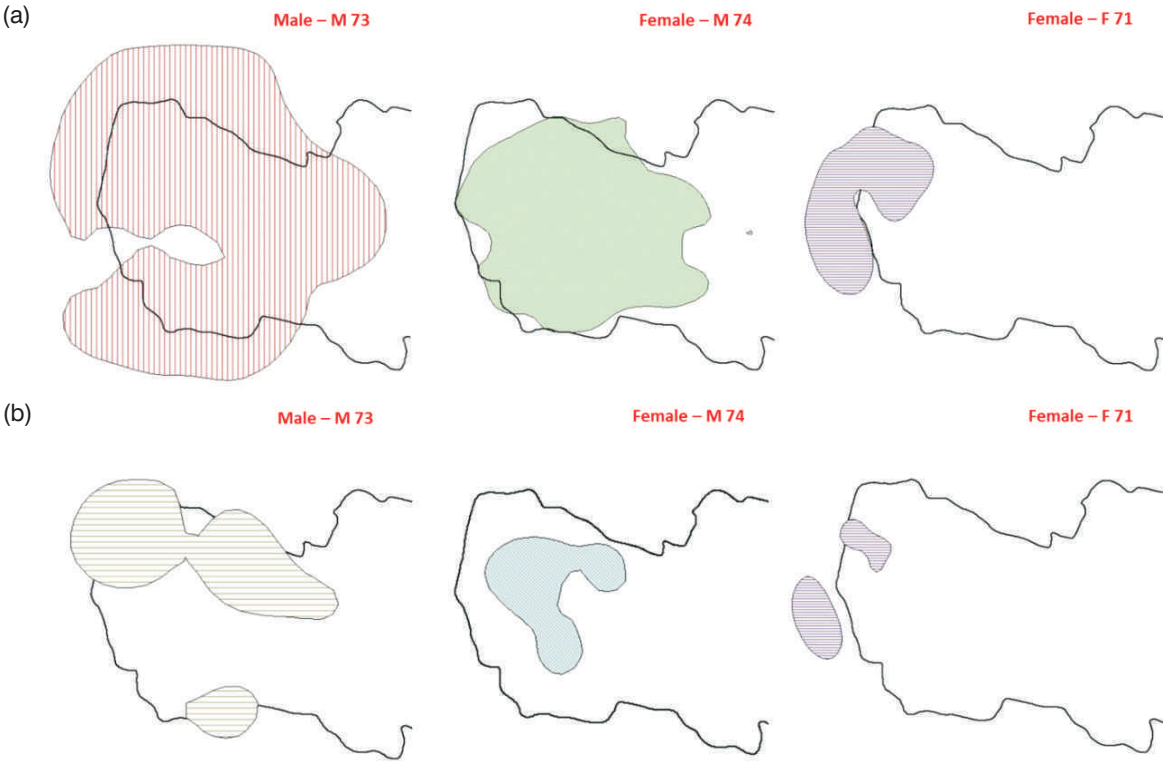

Fig. 4.10: *(a) 90% Fixed Kernel Home Ranges of Leopards; and (b) 50% Fixed Kernel Home Ranges of Leopards in Dachigam National Park*

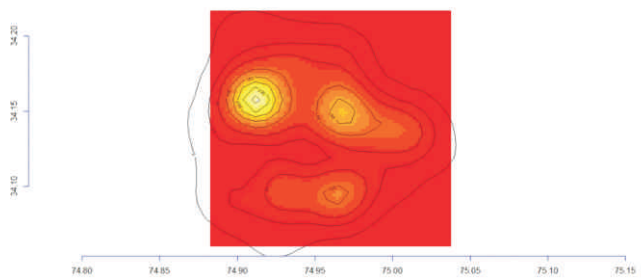

Fig. 4.11 : *(a) Utilization Distribution contour map of male – M73. The yellow colour represents most used area*

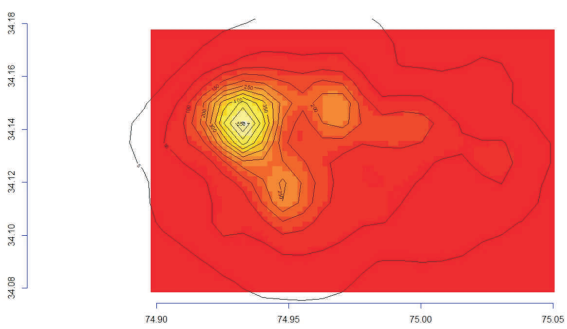

Fig. 4.11: *(b) Utilization Distribution contour map of female – F74. The yellow colour represents most used area*

Table 4.15: *Percentage overlap in 50% Fixed Kernel core areas of the leopards in Dachigam National Park.*

Collared Leopard ID	50% Fixed Kernel Overlap (%)		
	M 73	F 71	F 74
M 73	-	17.9	44.25
F 71	-	-	13.7
F 74	-	-	-

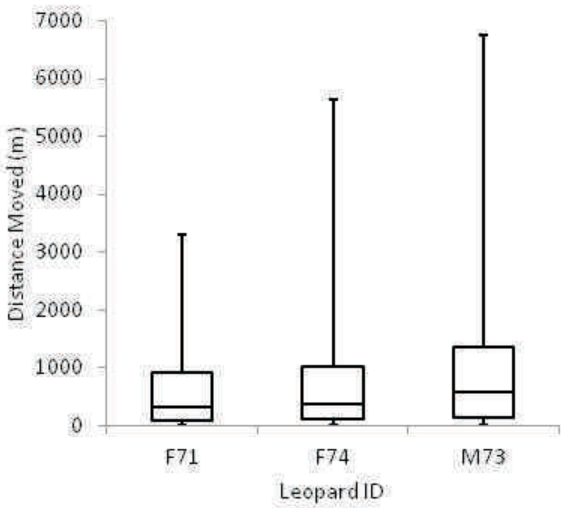

Fig. 4.12: *Daily displacements (m) of the three leopards in Dachigam National Park. For comparison summer data of female F74 is used. Error bars indicate the 75th and 25th percentiles, the line inside each box indicates the median, and lines represent the maxima and minima.*

Table 4.16: *Descriptive statistics of the distances moved between GPS fixes per day for the three leopards. The total distance travelled during the tracking period and the number of GPS fixes used in analysis for each leopard is also shown.*

Leopard ID	Daily distance moved between GPS fixes (km)				Total distance (km)	Number of Fixes used
	Minimum	Maximum	Median	Mean (±SE)		
M73	0.021	6.75	0.588	0.895 ± 0.046	398.71	78
F71	0.021	3.30	0.309	0.599 ± 0.064	62.91	105
F74 (Overall)	0.021	9.78	0.479	0.855 ± 0.025	1475.53	1725
F74 (Seasonal)						
Winter	0.021	6.93	0.664	1.171 ± 0.090	248.45	212
Spring	0.021	6.29	0.506	0.842 ± 0.037	552.40	656
Summer	0.021	5.64	0.367	0.699 ± 0.037	374.16	535
Autumn	0.021	9.78	0.528	0.933 ± 0.063	300.52	322

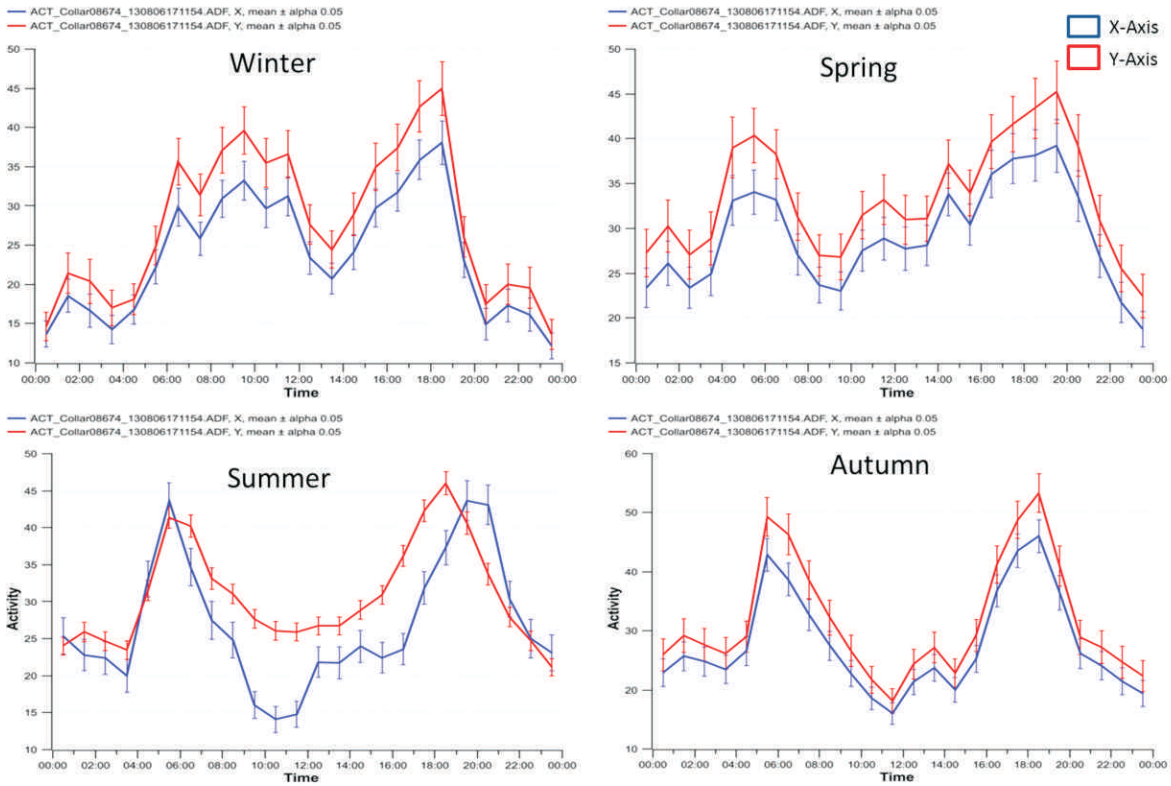

Fig. 4.13 (a). *Seasonal mean activity of female leopard – F74 on X (blue line) and Y (red line) axes representing forward-backward and lateral movements experienced by the collar, respectively.*

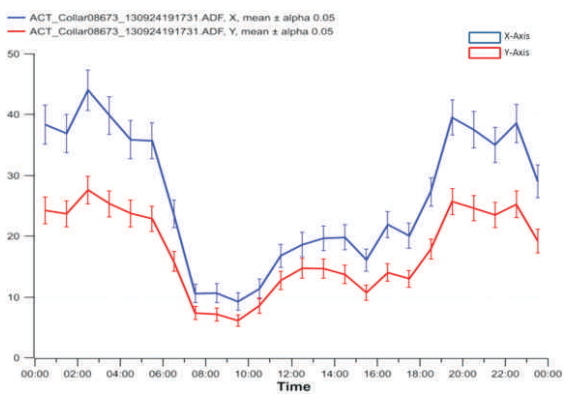

Fig. 4.13 (b). *Mean activity of male leopard – M73 on X (blue line) and Y (red line) axes representing forward-backward and lateral movements experienced by the collar, respectively.*

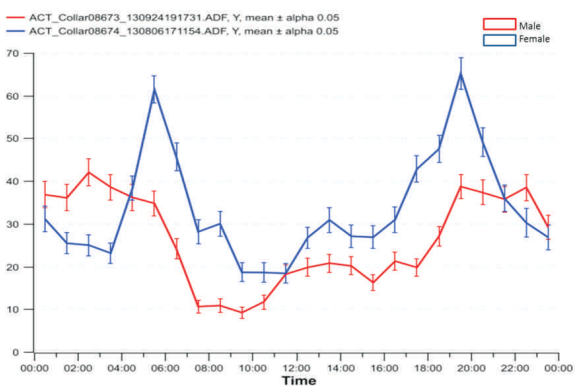

Fig. 4.13 (c). *Comparison of mean activity (on Y axis i.e. sideways or lateral movement) of male (M73) and female (F74) leopards during summer.*

DISCUSSION

5

Preeti Sharma

Prey Abundance

Overall prey availability in Dachigam National Park was found to be low. Only two potential large wild prey species are available in the form of langur and hangul with low population densities. Hangul density varied in different seasons with highest density in spring and lowest in summer season. In the recent past, Hangul population has shown a drastic decline from 3000 individuals reported in 1947 to around 218 animals estimated in 2011 (Ahmad 2006; Ahmad et.al. 2009; Qureshi et.al.2009). This decline may be attributed to large scale biotic interference, habitat fragmentation and degradation (Qureshi et al. 2009). The low fawn/ hind ratio is also considered as a major concern as high recruitment rate is essential for long term survival of any species (Qureshi et al. 2009). Summer range of the deer is heavily stocked with cattle, sheep and goat, acting as a major disturbance to hangul, moreover posing a threat of diseases transmission like rinderpest and John's disease from livestock to hangul (Schaller 1969).

Hangul density estimated in our study was lower than density of Red deer reported from other studies viz density of 15-20 deer /km^2 was reported by Clutton-Brock and Albon (1989) from Scotland and Red deer densities ranging from 7 deer/km^2 in Central Alps (Boccin & Lovari 2011) to 26 deer/km^2 area have been reported from Sardinia (Lovari et.al. 2007). Hangul density in our study also showed seasonal variation with lowest density recorded in summer season (2.31 km^{-2}) and highest in spring season (9.51 km^{-2}). This can be attributed to seasonal movements of hangul governed by resource availability. Prey species in other areas have also been reported showing such seasonal movements in relation to resource availability (Fuller 1991 and Peterson 1977). In case of Dachigam NP Hangul try to aggregate in lower Dachigam during winter season to exploit the food resources available, as lower areas experience lesser snowfall. And when unfavorable conditions subside they again expand their range to upper areas.

Average group size of hangul was estimated to be 3.14± 0.21 which varied with seasons. The changes in group sizes with seasonal and regional variations in availability of food and with variations in predation threats and sex ratio have been demonstrated in Red deer early also (Rose et.al.1998). Group size variation in our study clearly infers that hangul tend to form strong associations in spring and winter months and segregate into smaller groups in hotter months. This might be due to higher resource availability in hotter months than in winter months, as Lowe (1966) also reported that deer appear to live in small groups and sexes are usually segregated when food and shelter is abundantly available.

Since there has been no previous study on population status of langurs in Dachigam the population trends in past are not clear. In this study overall population density of langurs was estimated to be 16.32 individuals/km^2 which is almost same as density of Himalayan grey langurs (16.01 /km^2) reported from the similar Himalayan ecosystem of Machiara National Park, Pakistan (Minhas et al 2012). Considerable fluctuation in density was seen across different seasons in our study area. Highest density was recorded in winter season (22.05 km^{-2}) and lowest in summer season (9.35 km^{-2}). Minhas et al., (2012) also reported fluctuation in langur population in Machiara NP due to migration of troops. Genus Semnopithecus has been studied extensively in Indian subcontinent, especially the species S. entellus (Hanuman langur). Density of Himalayan grey langurs in our study was estimated to be lower than densities of hanuman langurs reported elsewhere in India. Bagchi et al. (2003) estimated 21.7 individuals/km^2 in Ranthambore, Edgaonkar (2008) reported 28.3 individuals/km^2 in Bori-Satpura tiger reserve, Narasimmarajan et al (2012) reported 42.92 individuals/km^2 from Melghat Tiger Reserve, Maharashtra and highest density of 82.5 individuals/km^2 was estimated in Pench tiger reserve by Majumder et al. (2010).

Rodent density estimated during our study ranged from 11.72 animals /hectare to 20.14 animals /hectare which is higher than rodent density (5.16 animals/ ha) reported by Gupta (2011) from Sariska Tiger Reserve, Rajasthan. Low density in winter season is probably due to low temperatures and snow cover which may decrease rodent movements and hence trapping rate of rodents.

Prey biomass availability is crucial for sustaining big cat distribution and abundance. Low biomass availability has adverse effects on space requirement as well as reproductive potential of big cats. Cats especially are likely to be more susceptible to dwindling prey resources than to direct human effects because they are able to withstand quite high human densities under favorable conservation and management policies (Karanth & Stith 1999; Linnell et al. 2001). In the present study, the total available prey biomass of large prey varied from 347.6 kg/km^2 to 886 kg/km^2 in different seasons, which is very less compared to studies conducted in other Himalayan ecosystems and rest of the Indian subcontinent like Ramesh et al. (2009) reported standing prey biomass of 8365.02 kg/km^2 from Mudumalai Tiger Reserve, Edgaonkar(2008) in Satpura national park reported available biomass of 6611.96kg/km^2 and Ramesh et al (2012) from Kalakad-Mundanthurai Tiger Reserve estimated prey biomass of 2614 kg/km^2. The lowest

prey biomass (379 kg/km^2) has been reported in the Eastern Himalayas at Jigme Singye Wang chuck National Park in Bhutan (Wang, 2010). In our study rodent biomass was estimated to be higher than hangul and langur in summer season while as hangul biomass was highest in all other seasons. High rodent density can be attributed to low ungulate densities as it has been reported that ungulates can compete with rodents for forage, and reduced ungulate densities can increase rodent numbers (Keesing 2000).

Food habits of leopard

Leopard diet has been studied in different ecosystems across many countries and is found to have a wide range of prey of varying size (Hayward et al., 2006). In Africa, leopards prey mainly on medium-sized (20 – 80 kg) ungulates in savannah habitats (Bailey, 1993), while consuming smaller prey (<5 kg) more often in rainforests, possibly due to differing abundance and profitability (Ray and Sunquist, 2001). Study in Nagarhole, India, shows leopards to select medium-sized prey (31 – 175 kg, Karanth and Sunquist, 1995). Leopards also take substantial small-sized prey in the 5-30 kg range (Karanth and Sunquist, 1995; Ray and Sunquist, 2001; Hart et al., 1996). Choice of prey is influenced by prey availability, abundance, and vulnerability (Emmons, 1987; Iriarte et al., 1990). Prey scarcity affects felids by decreasing the proportion -of productive females, delaying the age of first reproduction, reducing litter size, increasing offspring and adult mortalities, expanding home ranges, intensifying movements and increasing the numbers of transients and dispersing individuals – all of which worsen facets of viability (Fuller & Sievert 2001). In general carnivores are likely to switch their diet to secondary or sub optimal prey when the primary prey species is scarce (Hamilton, 1981; Seidensticker et al., 1990; Santiapillai and Ramono, 1992; Bailey, 1993).

In Dachigam NP prey availability is low, so leopards being opportunistic feeders have shifted their diet to sub optimal prey available in the form of small mammals. Rodents comprised major proportion of leopard diet in all the four seasons during the study period. Earlier Shah et al. (2009) have reported 15.7% rodents in the leopard diet in Dachigam NP. Sankar and Johnsingh (2002) also reported high (45.6%) contribution of rodents in leopard diet from Sariska. While Selvan et al (2013) reported 22.6% contribution of rodents to leopard diet in Pakke Tiger Reserve. Seasonal variation in leopard diet is attributed to variation in large prey availability due to migration of prey species. In summer season availability in terms of large prey decreases as langur and hangul densities are lowest and rodent densities are highest, thus leopard consumes rodents on large scale in summer season. Domestic prey in the form of sheep, goat, dog and cow contributed 25.13 % (biomass consumed) in leopard diet overall. This percentage also varied with season, highest consumption was noted in summer season when large wild prey availability is low and people let livestock out for grazing. During winter livestock usually remain confined to livestock sheds, thus reducing chance of leopard predation. Our study also indicated leopard predation on other carnivore competitors viz Black bear and Jackal contributed 5.38% and 1.64% respectively in terms of biomass consumed. There are numerous reports from other areas where leopards predate upon other competing carnivores (Hamilton, 1976; Bailey, 1993; Bothma et al., 1997; Stander et al., 1997; Mills & Funston, 2003).

Table 5.1: *Percent frequency of occurrence of major prey species in leopard (Panthera pardus) diet reported in studies from Indian subcontinent.*

Species	Present Study	Dachigam NP[1]	Sariska TR[2]	Sanjaya NP[3]	Mundanthurai TR[4]	Chitwan NP[5]	Bardia NP[6]
No. of scats	714	96	125	90	111	263	103
Rodents	48.05	15.7	45.6	19.95	7.41	4.62	10.5
Primates	14.14	21	6.4	8.72	10.17	3.55	9.2
Livestock	14.75	18.3	NP	11.31	8.33	10.21	17.1
Dog	6.05	21	NP	48.70	6.48	1.46	NP
Hangul	2.05	18.4	NP	NP	NP	NP	NP
Birds	1.84	0.8	4.8	NP	NP	1.59	4
Others*	13.12	4.8	43.2	11.31	67.61	78.57	59.2

Source: *[1]Shah et al. (2009); [2]Sankar and Johnsingh (2002); [3] Edgaonkar and Chellam (2002); [4]Ramakrishnan et al. (1999); [5]Thapa (2011); [6] Eliassen (2003). *Others include prey species which are either absent or found in low percentage in leopard scats in Dachigam.*

Predation of hangul by leopard has been a point of concern for conservationists for quite a long time. Hangul being critically endangered and showing declining population trend is presumed to be predated by leopards on a large scale. But our study clearly shows that hangul only contributes 5.47 % to leopard diet in terms of the biomass consumed. This consumption also varies with season, being highest in colder months and lowest in summer months. This is in concordance with varying seasonal density of hangul in the study area.

Prey selection

When a predator kills a species more frequently than expected based on its availability it is considered as preferred prey species, while if the predator takes proportionally fewer prey than expected based on availability then it is an avoided prey species (Hayward et al 2005). Apart from availability there are an array of factors affecting prey preference of a predator, which vary with area, conditions and species. Prey selection reflects not just the predator's preference but also the ease with which prey is captured (Schaller, 1972). In our study leopards consumed rodents and langur more than their availability in all the four seasons and hangul was avoided in all the seasons. Langur body weight is well within the preferred weight range of leopard prey so it is quite likely that leopards consume proportionally more langurs than their availability as no other prey of similar weight range is available. Further leopard's arboreal and cryptic nature (Karanth & Sunquist, 1995) helps them to predate easily upon langur. Rodents being easy to catch are seen preferred in all the four seasons as sufficient large prey is not available. This emphasizes on the leopard's opportunistic behavior and its ability to efficiently feed upon a wide range of prey including small rodents. The explanation for avoidance of hangul is that it is a large sized ungulate with an average body weight of 110 kg which exceeds the upper limit of leopard's preferred weight range (10 - 40 kg; Hayward et al, 2006) by a good margin. Further spatio-temporal distribution, defenses and anti-predatory tactics opted by hangul may be defending them against leopard. As a solitary hunter, the leopard cannot be sustained by other conspecific members if injured; hence it preys upon species where the risk of injury is minimal (Hayward et al., 2006).

Population Estimation of Leopard

The model selection algorithm of CAPTURE identified M_0 as the most appropriate model, followed by the model M_h. Model M_0 is thought to be too simplistic for free-ranging animals (Jackson et al. 2005) because of its underlying assumptions. This model assumes homogeneous capture probabilities

throughout the survey period, therefore, no behavioural responses to capture incidences and no variation in the experimental situation over time (Otis et al. 1978). These assumptions are usually unrealistic, and estimators of population size based on these are known to be sensitive to violations thereof (Otis et al. 1978, Karanth & Nichols 1998). However, the M_0 model is useful in testing for sources of variation and providing a basic model upon which to base generalisations about capture probabilities (Otis et al. 1978, White et al. 1982). However, the M_h model and its jackknife estimator are thought to be the more robust of the two models (Otis et al. 1978, Karanth & Nichols 1998). The M_h model is selected in most capture-recapture camera-trapping surveys (Karanth & Nichols 1998, Kawanishi & Sunquist 2004, Soisalo & Cavalcanti 2006, Balme et al. 2009a, Wang & Macdonald 2009) as the model allows for variation of capture probabilities among individuals, whilst each individual's probability of being recaptured remains constant over the sampling period (Karanth & Nichols 1998, Soisalo & Cavalcanti 2006). One would expect that leopard capture probabilities would be heterogeneous among individuals, due to age and sex specific behaviour (Otis et al. 1978, Trolle & Kery 2003, Wang & Macdonald 2009), and therefore this model fits the data and expectations well. However, one of the assumptions of the Mh model is that there is no behavioural response to capture (Otis et al. 1978). This assumption is likely to be violated by any camera-trapping survey that employs baits or lures to attract animals to the traps, or where the study animal has any favourable or unfavourable experience at the trap (Otis et al. 1978). On comparison with other studies from the Indian sub-continent our estimates of leopard density are the lowest ones (Table 5.2). On the other hand, Wang & Macdonald (2009) found that in the mountainous and rugged terrain region of the eastern Himalaya the leopard density is too low (1.04 ± 0.01 individuals per 100 km^2) which is also lower than our density estimate of 2.11 ± 1.06 individuals per 100 km^2. Several studies (Schaller 1967, Seidensticker 1976, Sunquist 1981, Karanth and Sunquist 2000) have previously observed that leopards are more active at dusk and dawn than during the day so is the case with leopards in Dachigam. But activity pattern within a species has been found to vary with geographical location, climate and the distribution of prey and interaction with other species (Leuthold 1977).

Table 5.2: *Comparison of leopard densities from different protected areas of the Indian subcontinent.*

Location	Trap nights	ETA	Mt+1	N±SE	D±SE/100 km^2	Study
Dachigam NP	396	186	3	3.92 ± 1.39	2.11 ± 1.06	This study
Pakke TR	1800	106.8	3	3.0 ± 3.5	2.8 ± 0.11	Selvan (2014)
Mudumalai TR	1400	147.3	27	26.0 ± 2.5	25.5 ± 4.2	Ramesh (2011)
Chilla	450	86.72	8	13.0 ± 6.9	14.9 ± 6.9	Harihar (2007)
Sariska	896	213.8	14	14.0 ± 0.2	7.0 ± 0.2	Sankar et al., (2008)
Sariska	4080	231.5	14	22.2 ± 3.6	10.7 ± 1.8	Mondal et al., (2012)
Satpura	660-1216	119 - 152	8-11	9-14 ± 2.6-6.9	7.3-9.3 ± 2.1-5.1	Edgaonkar et al., (2008)
Jigme Singye Wangchuk	4040	1506	16	16.0 ± 2.91	1.04 ± 0.01	Wang & Macdonald (2009)

Ranging and movement pattern

In large territorial carnivores, there is an inverse relationship between food availability and territory size (Ebersole 1980, Hixon 1980, Schoener 1981, Gittleman & Harvey 1982, Saitoh 1991). This relationship is quite evident from the studies conducted elsewhere in the dry arid areas of the African continent, where prey scarcity forces the

carnivores to travel longer distances to forage and thus, large home range sizes which range from 160 km^2 to 2182.4 km^2 (e.g. Norton & Lawson, 1985, Grimbeek, 1992, Bothma et al., 1997, Stander et al, 1997, Marker & Dickman, 2005, Swanepoel, 2008, McManus, 2009, Chase-Grey, 2011). On the other hand, this study presents largest home ranges in the south-east Asian countries (Table 5.3). Even, the estimates of home ranges of this study are much higher than the studies conducted in similar Himalayan ecosystems (e.g. Seidensticker et al., 1990; Odden & Wegge, 2005). This large difference in the home range sizes can be attributed to low prey availability in this study area which is considered to influence the home range sizes in carnivores (see Table 5.3). The basic social organisation of solitary felids is governed by the limiting resource; which is food for females and access to females for the males. This type of organisation is a common feature among leopards throughout their distribution range (Odden & Wegge, 2005) and is more pronounced in the study areas like those of Africa where home ranges are typically very large. Thus, males expand their ranges proportionally more than females in areas where resources are more sparsely distributed and hence, the cost of traversing larger home ranges cannot be a determinant factor of shaping leopard communities (Odden & Wegge, 2005).

In this study the female has large home range in comparison to other studies conducted elsewhere which can be attributed to low food availability in our area (Table 5.3). Seasonally also, the maximum home range turned out to be during the summer season (~74 km^2 for female, ~145 km^2 for male; 100 % MCP) when the potential large prey hangul and langur move to higher elevations in search of suitable food. During the winter season, climatic conditions (like snow) limit the movement of the animals to lower elevations only; that is why the home range during this season is the smallest in size (~41.4 km^2 for female;100 % MCP).

The difference in day-to-day movement of the two sexes (male: female) was 1.6:1, and thus, similar to the sexual difference in range size (1.9:1). This could be due to longer distances moved by males every day in order to regularly frequent all parts of its territory and can be attributed to more linear movement pattern of the male. Moreover, female (F74) travelled more distance during the winter season in search of potential prey when its home range size was the least, while on the other hand, lesser distances were covered during summer when home range got maximum in size due comparatively more availability of smaller mammalian prey during this period.

Activity Pattern

The leopards are known to be nocturnal in their predation strategies and mostly hunt during late hours of the day and early morning hours thereby, showing bimodal activity periods. This has been confirmed by the activity data we obtained through the collars (Fig. 4.13a-c). Female tends to be more active than the male (Fig. 4.13c) as well as it showed more activity all day round during winters in comparison to summers (Fig. 4.13a). This can be attributed to maintain body heat by being more active during winters.

Table 5.3: *Comparative analysis of home ranges of leopard from different studies in Asia.*

Study area	Prey density (km^{-2})	Home range size (km^{-2})		Reference
		Male (n)	Female (n)	
Dachigam N. P, India	21	145.39 (1)	54.16 (2)	Present study
Bardia N. P, Nepal	200	47.4 (2)	16.9 (1)	Odden and Wegge 2005 & 2009
Royal Chitwan N. P, Nepal	-	-	8.7 (3)	Seidensticker et al. 1990
Nagarhole N. P, India.	91	26.2 (2)	-	Karanth and Sunquist 2000
Huai kha khaeng WLS, Thailand	-	27.0 (1)	11.4 (1)	Rabinowitz 1989
Kaeng Krachan N. P, Thailand	-	17.7 (2)	8.8 (1)	Grassman 1999
Tadoba-Andhari TR, India	24.4	-	68.2 (1)	Bilal Habib (unpb. data)

This report serves to show for the first time the results of a detailed study on leopard ecology in the Dachigam National Park of the Western Himalayas. This study highlights the status of the leopard which was previously not known. The present study provides valuable baseline information shedding light onto its abundance, ranging behavior, feeding habits and to some extent information regarding problems faced by leopard in terms of resource availability. The future works on the ecological aspects of leopard should consider the present outcomes as a starting reference as the area covered under this study was limited. There is huge potential for future works to be conducted across the whole Kashmir Himalayas. The conservation of any species and its scientific management if strongly based on scientific information will be more effective and logical. Since, leopard is the top order predator in the Kashmir Himalayan ecosystem its conservation and management requires scientific inputs so that the whole ecosystem is conserved and managed. Sound scientific database needs to be setup by conducting research in areas like leopard-human conflict and socio-economic relationships of the local communities with their environment and natural resources so as to manage the ecosystem sustainably. Findings of this study indicate that leopards are facing prey scarcity in the area, thus making them to rely upon suboptimal prey and occupy home ranges larger than other studies in the subcontinent. Leopards being opportunistic feeders have also started feeding on domestic prey in absence of sufficient wild prey, thereby elevating the human - leopard conflict in the region. Human - animal conflict being the major threat to large carnivores all across their distribution range is a big impediment in leopard conservation in the study area as well.

In this study, first time GPS Collars were put on leopards captured and released within their home ranges whereas, most of the other studies have used such technologies on leopards captured from conflict affected areas and released in other areas.

S&T benefits accrued:

i. List of research publications

S no.	Author	Title	Journal	Year
1.	Khursheed Ahmad, Parag Nigam, **Bilal Habib,** M. Sadiq Mir, **Zaffar Rais,** Mehraj udin Shah, and Nazir A. Malik.	Reappearance of the wild pig *Sus scrofa cristatus* in Dachigam National Park, Kashmir, India	Journal of Bombay Natural History Society	2013
2.	**Zaffar Rais Mir Athar Noor Bilal Habib Gopi G. V.**	Attitudes of local people towards wildlife conservation: a case study from the Western Himalayas	NA	In preparation
3.	**Zaffar Rais Mir, Athar Noor, Bilal Habib, Gopi G. V.**	Seasonal dietary spectrum of leopard (*Panthera pardus*) in prey scarce conditions of the Western Himalayas, India	NA	In preparation
4.	**Athar Noor, Zaffar Rais Mir, Bilal Habib, Gopi G. V.**	Predicting habitat suitability of leopard (*Panthera pardus*) in Kashmir Himalayas	NA	In preparation
5.	**Athar Noor, Zaffar Rais Mir, Bilal Habib, Gopi G. V.**	Estimating population and modelling suitable habitat of leopard cat in a Western Himalayan region	NA	In preparation

ii. Manpower trained on the project

a) Number of Ph.D registered: Two

S no.	Name of candidate	Title	Date of registration
1	Zaffar Rais Mir	Monitoring Prey Dynamics and Diet Fluctuations of Leopard (Panthera pardus) in Dachigam National Park, Srinagar, Jammu and Kashmir.	01.01.2012
2	Athar Noor	Status and Spatio-Temporal Ranging Behaviour of Leopard (Panthera pardus) in Dachigam National Park, Srinagar, Jammu and Kashmir.	01.01.2012

b) Number of M. Sc Dissertations Completed: Two

S no.	Name of student	Title	Institute / University	Year
1	Amlendu Pathak	Winter Habitat use of Hangul (Cervus elaphus hanglu, Wagner) in Dachigam National Park, Srinagar, Kashmir.	FRI University Dehradun	2011
2	Bhaskar Bora	Food Habits of Red Fox (Vulpes vulpes) in Dachigam National Park, Srinagar, Jammu and Kashmir, India.	Doon University Dehradun	2012

Bivash Pandav

Financial Position

Total Project cost: Rs. 37,81,800 (Rupees thirty seven lakh eighty one thousand eight hundred only)

Funds released till date: Rs. 36,00,000 (Rupees thirty six lakh only)

Interest generated Rs. 1,25,336 (Rupees One lakh twenty five thousand three hundred thirty six only)

No.	Financial Position/ Budget head	Funds released	Expenditure	% of Total cost
I	Salaries/ Manpower costs	1048800	1048800	28.15
II	Equipment	1285000	1285000	34.49
III	Supplies & Materials	398000	398000	10.68
IV	Contengencies	200000	200000	5.37
V	Travel	350000	350000	9.40
VI	Overhead Expenses	443536	443536	11.91
VII	Others, if any	0	0	0
	TOTAL	**3725336**	**3725336**	**100**

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Appendix I

BIRD SPECIES RECORDED IN DACHIGAM NATIONAL PARK

Family	Common name	Scientific name	Status
Family- Accipitridae			
1	Black Kite	*Milvus migrans*	R
2	Sparrow Hawk	*Hiereatus nisus nisosimilis*	RM
3	Booted Eagle	*Hiereatus pennatus*	RM
4	Golden Eagle	*Aquila chrysaetos*	R
5	Eurasian Griffon	*Gyps fulvus*	RM
6	White-Rumped Vulture	*Gyps bengalensis*	R
7	Bearded Vulture Or Lammergier	*Gypaetus barbatus*	R
Family- Falconidae			
8	Common Kestrel	*Falco tinnunculus*	RM
Family- Phasianidae			
9	Snow Partridge	*Lerwa lerwa*	R
10	Himalayan Snowcock	*Tetraogallus himalayensis*	R
11	Chukar	*Alectoris chukar*	R
12	Western Tragopan	*Tragopan melanocephalus*	R
13	Himalayan Monal	*Lophophorus impejanus*	R
15	Koklass Pheasant	*Pucrasia macrolopha*	R
Family- Columbidae			
16	Snow Pigeon	*Columba leuconota*	R
17	Rock Pigeon	*Columba livia*	R
18	Oriental Turtle Dove	*Streptopelia orientalis*	RM
19	Eurasian Collared Dove	*Streptopelia decaocto*	R
20	Red Collared Dove	*Streptopelia tranquebarica*	R
21	Spotted Dove	*Streptopelia chinensis*	R
Family- Psittacidae			
22	Rose-Ringed Parakeet	*Psittacula krameri*	R
23	Slaty-Headed Parakeet	*Psittacula himalayana*	R
24	Indian Cuckoo	*Cuculus micropterus*	RM
25	Eurasian Cuckoo	*Cuculus canorus*	RM
Family- Strigidae			
26	Eurasian Eagle Owl	*Bubo bubo*	R
27	Little Owl	*Athene noctua*	R
28	Long-Eared Owl	*Asio otus*	RM
Family- Aodidae			
29	Himalayan Swiftlet	*Collocalia brevirostris*	R
30	Alpine Swift	*Tachymarptis melba*	RM
31	Common Swift	*Apus apus*	M
32	House Swift	*Apus affinis*	RM
Family- Alcedinidae			
33	Pied Kingfisher	*Ceryle rudis*	R
34	Common Kingfisher	*Alceodo atthis*	RM

Family	Common name	Scientific name	Status
35	White-Throated Kingfisher	*Halcyon smyrnensis*	R
Family- Coraciidae			
36	European Roller	*Coracias garrulus*	RM
Family- Upupidae			
37	Common Hoopoe	*Upupa epops*	RM
Family- Picidae			
38	Eurasian Wryneck	*Jynx torquilla*	M
39	Scaly-Bellied Woodpecker	*Picus squamatus*	R
40	Grey-Headed Woodpecker	*Picus canus*	R
41	Himalayan Woodpecker	*Dendrocopos himalayensis*	R
Family- Alaudidae			
42	Crested Lark	*Melanocorypha bimaculata*	R
Family- Hirundinidae			
43	Dusky Crag Martin	*Hirundo concolor*	R
44	Barn Swallow	*Hirundo rustica*	RM
45	Striated Or Redrumped Swallow	*Hirundo daurica*	R
Family- Oriolidae			
46	Eurasian Golden Oriole	*Oriolus oriolus*	RM
Family- Surnidae			
47	Common Starling	*Sturnus vulgaris*	RM
48	Common Myna	*Acridotheres tristis*	R
49	Jungle Myna	*Acridotheres fuscus*	
Family- Corvidae			
50	Yellow-Billed Blue Magpie	*Urocissa flavirostris*	R
51	Rufous Treepie	*Dendrocitta vagabunda*	R
52	House Crow	*Corvus splendens*	R
53	Large-Billed Crow	*Corvus macrorhynchos*	R
54	Nutcracker	*Nuctifraga caryocatactes*	
55	Yellow-Billed Or Alpine Chough	*Pyrrhocorax graculus*	
56	Eurasian Jackdaw	*Corvus monedula*	
57	Raven	*Corvus corax*	
58	Jungle Crow	*Corvus macrorphynchos*	
Family- Pycnonotidae			
59	White-Cheeked Bulbul	*Pycnonotus leucogenys*	
60	Black Bulbul	*Hypsipetes madagascariensis*	R
Family- Muscicapidae			
Sub. Family- Timalinae			
61	Jungle Babbler	*Turdoides striatus*	
62	Striated Laughing Thrush	*Garrulax striatus*	
63	Variegated Laughing Thrush	*Garrulax ariegatus*	
64	Streaked Laughing Thrush	*Garrulax lineatus*	

Family	Common name	Scientific name	Status
Sub. Family- Muscicapinae			
65	Kashmir Redbreasted Flycatcher	*Muscicapa subrubra*	
66	Little-Pied Flycatcher	*Muscicapa westermannt*	
67	White-Browed Blue Flycatcher	*Muscicapa supercillaris*	
68	Slaty Blue Flycatcher	*Muscicapa leucomelanura*	
69	Verditer Flycatcher	*Muscicapa thalassina*	
70	Grey-Headed Flycatcher	*Culicicapa ceylonensis*	
71	Paradise Flycatcher	*Terpsiphone paradist*	RM
Sub. Family- Sylvinae			
72	Plain Leaf Warbler	*Phylloscopus neglectus*	R
73	Tytler's Leaf Warbler	*Phylloscopus tytleri*	R
74	Tickell's Leaf Warbler	*Phylloscopus affinis*	R
75	Sulphur-Bellied Warbler	*Phylloscopus griseolus*	RM
76	Yellow-Browed Warbler	*Phylloscopus inornatus*	R
77	Lemon-Rumped Warbler	*Phylloscopus chloronotus*	R
78	Blyth's Leaf Warbler	*Phylloscopus reguloides*	RM
79	Gold Crest	*Regulus regulus*	
Sub. Family- Turdinae			
80	Orange-Flanked Bush Robin	*Tarsiger cyanurus*	
81	Blue-Capped Redstart	*Phoenicurus caeruleocephala*	R
82	Black Redstart	*Phoenicurus ochruros*	R
83	White-Winged Redstart	*Phoenicurus erythrogastrus*	
84	Plumbeous Water Redstart	*Rhyacornisfuliginosus*	R
85	Little Forktail	*Enicurus scouleri*	M
86	Spotted Forktail	*Enicurus maculates*	
87	White-Capped Water Redstart	*Chaimarrornis leucocephalus*	R
88	Blue Rock Thrush	*Monticola solitarius*	R
89	Blue Whistling Thrush	*Myophonus caeruleus*	R
90	Grey-Winged Blackbird	*Turdus boulboul*	
91	Chestnus Thrush	*Turdus rubrocanus*	
Family- Troglodytidae			
92	Winter Wren	*Troglodytes troglodytes*	
Family- Cinclidae			
93	White-Throated Dipper	*Cinclus cinclus*	
94	Brown Dipper	*Cinclus pallasii*	
Family- Prunillidae			
95	Alpine Accentor	*Prunella collaris*	
96	Altai Accentor	*Prunella hamalayana*	
Family- Paridae			
97	Grey Tit	*Parus major*	
98	Green-Backed Tit	*Parus moniticolus*	
99	Crested Black Tit	*Parus melanolophus*	
100	Black Tit	*Parus rufonuchalis*	
101	Yellow-Cheeked Tit	*Parus xanthogenys*	

Family	Common name	Scientific name	Status
102	Fire-Capped Tit	*Cephalopyrus flammiceps*	
103	White-Throated Tit	*Aegithalos niveogularis*	
Family- Sittidae			
104	European Nuthatch	*Sitta europaea nagansis*	
105	White-Cheeked Nuthatch	*Sitta leucopsis*	
Family- Certhidae			
106	Tree Creeper	*Certhia familiaris*	
107	Himalayan Tree Creeper	*Certhia himalayana*	
Family- Motacillidae			
108	Yellow Wagtail	*Motacilla flava*	
109	Grey Wagtail	*Moctacilla cinerea*	
110	Pied Or White Wagtail	*Motacilla alba*	
111	Large Pied Wagtail	*Motacilla maderaspatensis*	
Family- Zosteropidae			
112	White Eye	*Zosterops palpebrosa*	
Subfamily- Passerinae			
113	House Sparrow	*Passer domesticus*	
114	Russet Sparrow	*Passer rutilans*	
115	Eurasian Tree Sparrow	*Passer montanus*	
Family- Campephagidae			
116	Scarlet Minivet	*Pericrocotus flammeus*	
117	Long-Tailed Minivet	*Pericrocotus ethologus*	
118	Small Minivet	*Pericrocotus cinnamomeus*	
Family- Emberizidae			
119	Pine Bunting	*Emberza leucocephalos*	
120	White-Capped Bunting	*Emberiza stewarti*	
121	Grey-Necked Bunting	*Emberiza bunchanani*	
122	Rock Bunting	*Emberiza cia*	

Source: Management Plan, Dachigam National Park. R = Resident, M = Migrant

Camera trap pictures of species reported from DNP during this study period








भारतीय वन्यजीव संस्थान
Wildlife Institute of India
P.O. Box # 18, Chandrabani
Dehradun - 248 001 (Uttarakhand)
t. (0135) 2646283; **f.** 0135-2640117
w. www.wii.gov.in; **e.** bh@wii.gov.in

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